MODERN ELECTRIC AND GAS REFRIGERATION

ALTHOUSE and TURNQUIST

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By

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Modern Electric and Gas Refrigeration

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PREFACE TO THE FOURTH EDITION

In bringing this book up to date at this time (1943), the authors recognize the problems that may be encountered in serving many refrigerators and have included suggestions which should help the service student in making satisfactory repairs and adjustments with a minimum amount of replacement of parts and refrigerants.

New service tools and methods have been included in this edition which should aid the beginner as well as the experienced refrigerator service man in making repairs and adjustments quickly and accurately.

In addition to the companies which cooperated with us in supplying data and illustrations for the first three editions, we wish to acknowledge the assistance of the following companies who have made contributions to the fourth edition:

Mueller Brass Company
Highside Chemicals Company
Rotary Seal Company

ANDREW D. ALTHOUSE
CARL H. TURNQUIST

Detroit, Michigan
August, 1943

PREFACE TO THE THIRD EDITION

The third edition has been enlarged in certain sections to further its original purpose as a textbook. Specifications have been brought up to date and illustrations have been added, showing some new features in design.

Some of the new commercial motor controls are explained and illustrated, and also the National Refrigerating Code has been brought up to date to conform to the New Code put in effect April 20, 1939.

In addition to the companies which co-operated in supplying data for the first and second editions, the authors wish also to acknowledge the assistance of the following companies:

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Kerotest Manufacturing Company

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Detroit, Michigan
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PREFACE TO THE SECOND EDITION

This book is planned to serve as a school textbook in modern refrigeration. Both domestic and commercial applications are studied in some detail. The principles of physics essential to a thorough understanding of refrigerator mechanisms are arranged for study in the first chapter.

All of the common types of refrigerators are covered very thoroughly. Particular attention is given to the principles of construction and operation of complete refrigerator machines. This is done in order that the student may possess a good understanding of the relationship of the various parts of a mechanism to one another, also the relationship which exists between the types of systems and the construction of the parts within the system.

Several colored inserts are used to illustrate complete refrigeration cycles or portions of cycles of operation.

The chapters dealing with servicing contain suggestions which if followed should assist the beginner in eliminating the usual difficulties encountered in refrigeration service work.

The chapter of school projects should be useful in refrigeration classes since, in addition to detailed job instructions, lists of needed tools, equipment, and supply items are provided.

A chapter on air conditioning defines the scope of that subject, and also illustrates the common applications of refrigeration to air-conditioning installations.

The terminology used throughout the text has been kept uniform, although the refrigeration industry has not, as yet, adopted a uniform terminology.

The authors acknowledge the valuable assistance that has been given by the following organizations:

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Williams Oil-O-Matic Heating Corp

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Detroit, Michigan
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PREFACE TO THE FIRST EDITION

The material contained in this book is the result of teaching classes in domestic refrigeration for several terms in the Evening School Department of Cass Technical High School, Detroit, Michigan. As a result of this experience, it became evident that a suitable text for school use and home study must be prepared. This idea has been kept in mind throughout the preparation of this book. It is not expected that it is to replace in any way the service manuals published by refrigeration companies for their service men, but it should be a good elementary text for beginning service mechanics as a thorough understanding of the principles covered in this book should assist greatly in understanding the service instructions issued by the refrigerator manufacturing companies.

The field covered in this text is restricted entirely to domestic refrigeration and no attempt has been made to cover the field of commercial installations. However, as the basic principles of refrigeration are fundamental to both fields this text might well be used as a preliminary text for the study of commercial refrigeration.

All of the common types and most of the popular domestic refrigerators have been studied in some detail. The more conventional types, such as the electric compressor type and the gas-fired absorption type are given the greatest attention.

A chapter dealing with the essential principles of physics as they apply to refrigeration has been prepared for the student who has not had previous training in this subject. Experience has shown that for a good understanding of refrigeration, some knowledge of physics is necessary.

In compiling the material for the chapters dealing with servicing operations, suggestions have been given which the authors believe, in the light of their experience in refrigerator service

work, will be of most benefit to the beginner. Certain suggestions and precautions have been given, which if followed, will eliminate the usual difficulties encountered in refrigeration service work. Common refrigeration troubles, their symptoms, and remedies have been covered in some detail.

The terminology used throughout this text has been kept uniform, in spite of the fact that there is no standard terminology or nomenclature of parts as yet adopted by the industry. In general, the terminology used conforms to that used by several prominent manufacturers. However, it is not uniform with all of them. It is believed that the student will benefit more by a uniform terminology.

During the time that the manuscript was being prepared the authors were in constant touch with refrigerator manufacturers and refrigeration sales companies to the end that material has been made available that would have been impossible to obtain any other way.

We wish to acknowledge the valuable assistance that has been given by the following organizations:

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Williams Oil-O-Matic Heating Corp.

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Detroit, Michigan
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CHAPTER I

FUNDAMENTALS OF REFRIGERATION

1. HISTORY OF REFRIGERATION:

As far back as history can be traced, snow, ice, and cold water have been the aids of mankind in keeping his food supply in good condition. Even today in the warmer climates, porous vessels containing water are used to cool beverages and foods. Also, during the warmer months, food is kept in deep caves or just over the surface of water in deep wells.

Refrigeration, the industry of preserving food by cold, first became of commercial importance during the 18th century, when ice formed during the winter was cut and stored in insulated store rooms to be used during the summer. This practice was followed by shipping ice from the colder climates to the hotter zones, but it did not turn out successfully. The use of ice made necessary the building of insulated containers or ice-boxes and these first appeared on a large scale during the 19th century. Figure 1.

The first knowledge of artificial ice preparation and cold producing is recorded about 1820, but it was not until 1834 that this was successfully done. Jacob Perkins, an American engineer, was the inventor of this apparatus and his device was the forerunner of all of our modern compression systems. In 1855 a German produced the first absorption type of refrigerating mechanism although Michael Faraday discovered the principle of the absorption type in 1824.

The production of artificial ice made very little progress until shortly after 1890, during which year a big shortage of natural ice gave impetus to the mechanical ice-making industry. Since 1890, the growth of mechanical refrigeration in the United States has been only short of phenomenal.

Domestic refrigeration first made its appearance about 1910, but it was not until 1918 that the first automatic refrigerator was available on the American market (the Kelvinator). Mr. J. M. Larsen produced a manually operated household machine in 1913. The Kelvinator Company sold its first machine in 1918 and this Kelvinator was engineered by E. J. Copeland. In the year 1918, Kelvinator sold sixty-seven machines and

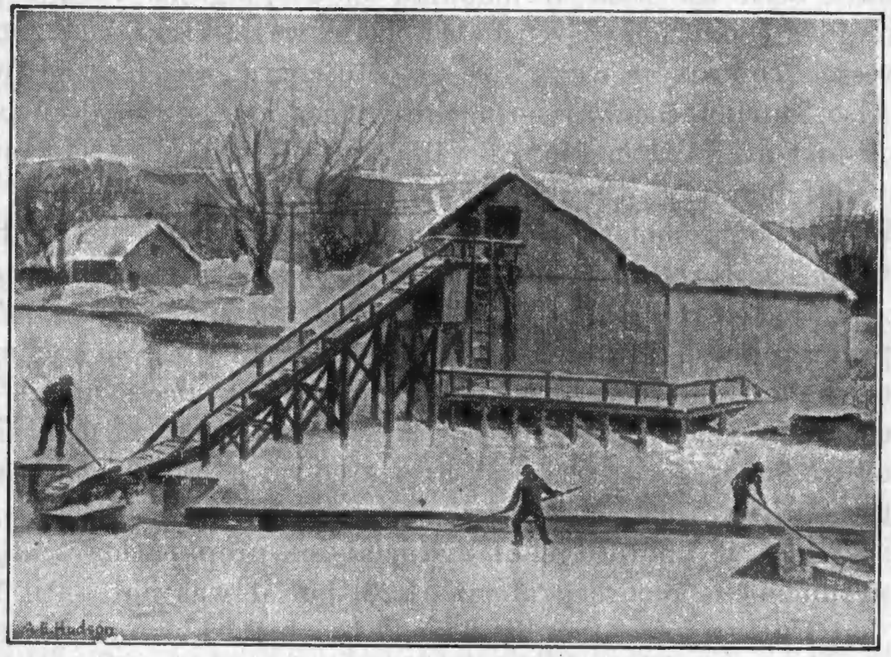


Fig. 1. Cutting and storing natural ice
(Courtesy of: General Electric Company)

between 1918 and 1920 two hundred units were sold. The General Electric Monitor Top appeared in 1926 after eleven years of experimenting. Beginning with 1920, domestic refrigeration became one of our important industries. The Electrolux appeared on the American market in 1927. Today there are over forty-five companies producing about 1,250,000 domestic refrigeration machines annually.

2. THE SCOPE OF MECHANICAL REFRIGERATION:

A prediction covering the future of domestic mechanical refrigeration is a difficult task, but just a few statistics will prove that the field is very large and that it is still almost virgin territory. There are at present in the United States about 25,000,000 families, all of whom have some need for refrigeration. Many of these households are equipped with the common ice-box which, although satisfactory, does not contain the many advantages of a mechanical refrigerator. The principal feature of the mechanical refrigerator is that it is practically automatic and keeps the food at the best possible preserving temperature, while the ice-box needs frequent replenishing to do this. Also, it has been shown that many ice-boxes do not maintain satisfactory refrigerating temperatures. At present, the mechanical refrigerator market is considered 15% saturated while in comparison the radio market is 85% saturated.

Every housewife wants the conveniences offered by an automatic refrigerator. Manufacturers have answered this demand by producing refrigerators selling from $75.00 to $250.00 for the average family. These refrigerators are completely automatic, long-wearing, and economical to operate. Most important of all, however, they actually do what they are intended to do, that is, preserve food at the best possible temperatures.

3. ELEMENTARY PHYSICS OF REFRIGERATION:

In order to understand the operation of the mechanical refrigerator, it is imperative to understand the physical and thermal properties of the mechanisms and of the substances used to produce artificial cold. A résumé of elementary physics is needed in order that all the explanations may be well understood. Service managers of refrigerator companies prefer

service mechanics who are well grounded in the essential principles of physics as it pertains to refrigeration.

4. DIMENSIONS, WEIGHT, AND MASS:

All measurements of distance are based on the English units such as, inches, feet, and yards.

12 inches (in.) = 1 foot (ft.)
3 feet (ft.) = 1 yard (yd.)
5280 feet (ft.) = 1 mile (mi.)

Two dimensional space (area) is also measured in foot and inch units; that is, a square inch or a square foot. 1 square inch is ■ square area with ■ 1 inch measurement on each side. Figure 2

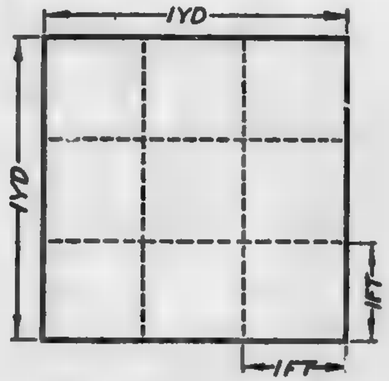


Fig. 2. The relation of standard areas

144 square inches (sq. in.) = 1 square foot (sq. ft.)
9 square feet (sq. ft.) = 1 square yard (sq. yd.)

Three dimensional space (volume) is also measured by the English units. All substances must be of three dimensions. These measurements are the cubic inch, the cubic foot, and the cubic yard.

1 cubic inch (cu. in.) is ■ cube, 1 inch (in.) on each dimension.

1728 cubic inches (cu. in.) = 1 cubic foot (cu. ft.)
27 cubic feet (cu. ft.) = 1 cubic yard (cu. yd.)

Figure 3

Mass is ■ property of all matter, for everything has mass. Gas has mass, air has mass, water has mass, and metals have mass. The weight of ■ substance is due to the earth's attraction on the substance (gravity). The only condition in which a substance has no weight is when it is falling in ■ vacuum under the influence of gravity. At all other times it has weight. Therefore, weight divided by acceleration due to gravity is mass.

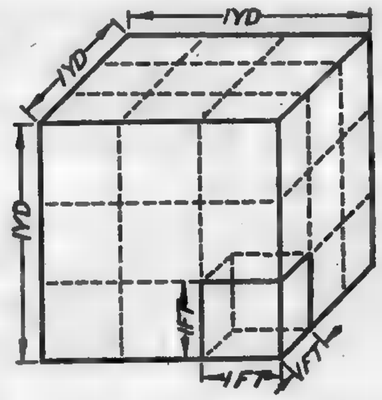


Fig. 3. The relation of standard volumes

$$\text{mass} = \frac{\text{weight}}{32.2 \text{ ft. per sec. per sec.}} = \text{slugs}$$

The unit of mass is the slug.

The English units for weight are the ounce, the pound, and the ton.

16 ounces (ozs.) = 1 pound (lb.)
2000 pounds (lbs.) = 1 ton (ton)

Example: What is the mass of a 10 lb. substance?

Mass is $= \frac{10}{32.2} = .3106$ slugs

W = Weight of substance
■ = acceleration due to gravity = 32.2 feet per second per second

5. SOLIDS, LIQUIDS, AND GASES:

Substances exist in three physical forms: the solid, the liquid, and the gaseous. Water, for example, may exist in any one of the above physical forms. If it is ice, it is a solid; if it is water, it is a liquid; while as steam, it is a gas. Three different methods are used to express physical properties of substances or materials corresponding to the three states of matter.

Comparative weights of solids and liquids may be expressed by either density or specific gravity. Density is defined as the weight per unit volume. Specific gravity is defined as the ratio of the weight of a certain volume of a substance to the weight of an equal volume of water.

Comparative densities of gases are expressed by specific volumes. Specific volume is the volume of one pound of a gas at standard conditions. Standard conditions are considered to be 68°F. and 29.92″ of mercury column. (See Figures 5 and 7.)

6. SYMBOLS:

°F. = Degrees Fahrenheit
°C. = Degrees Centrigrade
°F_A = Degrees Fahrenheit Absolute
°C_A = Degrees Centigrade Absolute
/ = per
= pounds
#/□″ = pounds per square inch
″ = inches
′ = feet
□″ = square inch
□′ = square foot
#/cu. ft. = pounds per cubic foot

Example: What is the specific volume of air if 10 cubic feet of it weighs .75 pounds?

$$\text{Specific Volume} = \frac{\text{Volume in cu. ft.}}{\text{Weight in lbs.}} = \frac{10}{.75} = 13.3$$

Example: If 1 cubic foot of iron weighs 490 pounds what is its specific gravity? Density of water = 62.4 pounds per cubic foot.

$$\text{Specific gravity of iron} = \frac{490 \text{ pounds per cubic foot}}{62.4 \text{ pounds per cubic foot}} = 7.85$$

Example: What is the density of ■ liquid if 3000 cubic inches weighs 108.5 pounds?

$$\frac{108.5 \text{ pounds} \times 1728 \text{ inches per cubic foot}}{3000 \text{ cubic inches}} = \frac{108.5 \times 1728}{3000}$$

density of the liquid = 62.4 pounds per cubic foot

7. PRESSURE:

As the operation of ■ refrigerator depends mainly on pressure differences in the system, ■ basic understanding of pressure and the laws of pressures is very important.

Pressure is defined as the weight per unit area, and it is expressed in pounds per square inch and pounds per square foot. That is, the pressure of the air on one's body averages about 14.7 pounds per square inch, or 2117 pounds per square foot. Note: There are 144 square inches in 1 square foot; therefore to get the pressure per square foot, 14.7 must be multiplied by 144.

Substances always exert a pressure upon the surfaces supporting them. That is, an ice-box (a solid) exerts a pressure on its legs because if they were removed the box would move; a liquid always exerts a pressure on the sides and bottom of its container, such as ■ bottle; and a gas always exerts a pressure on all the surfaces of its container, such as ■ balloon. Figure 4. If a weight of 1 pound were made with its bottom surface 1 inch square, it would always exert ■ pressure of 1 pound per square inch upon a flat surface. Liquids in ■ certain container maintain a constant pressure upon the sides and bottom

of their container. Gases, however, do not always exert constant pressure on their container because the pressure is determined by the temperature or volume.

8. PRESSURES—GAUGE AND ABSOLUTE:

Pressures are expressed in pounds per unit of area or in inches of static pressures of liquids. The most popular pressure indicating instruments register in pounds per square inch

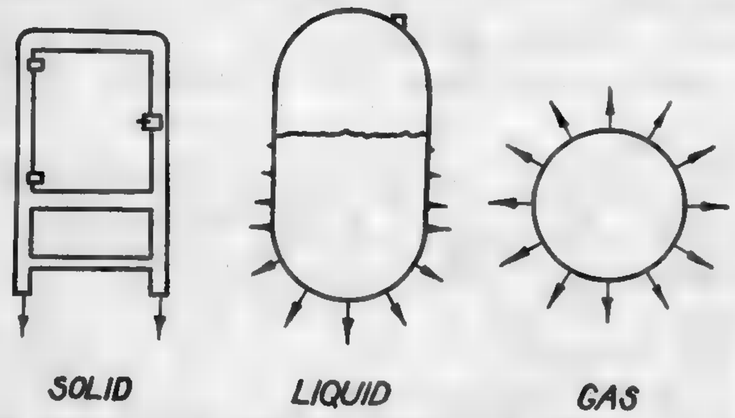
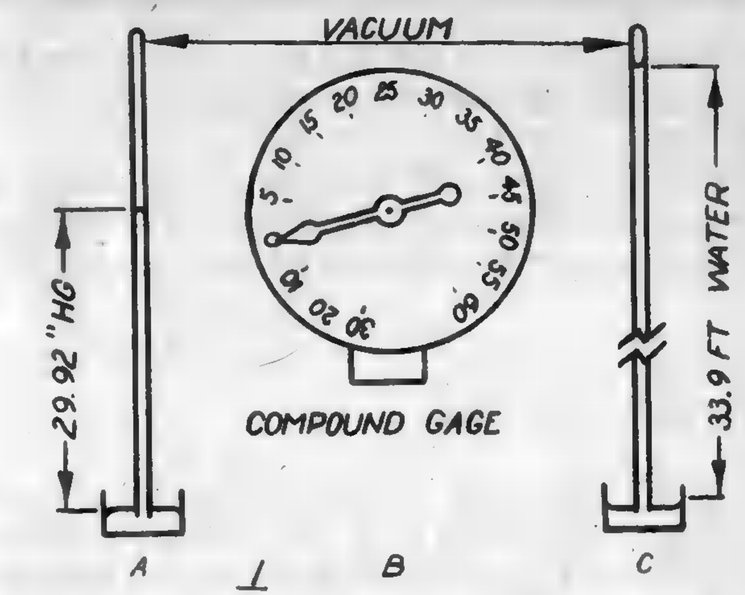


Fig. 4. The various ways materials exert pressure. The arrows represent the direction of and the relative amount of the pressures

above the atmospheric pressure. The pressure of zero pounds per square inch gauge is equal to the atmospheric pressure (approximately 14.7 pounds per square inch; 15 pounds per square inch is usually used for computation purposes). Pressures below atmospheric pressure are termed vacuums and ■ perfect vacuum may be described as −14.7 pounds per square inch gauge or 0 pounds per square inch absolute. Therefore, the absolute pressure scale has its zero at ■ pressure which cannot be further reduced. Pressure is also indicated in inches of mercury or water column and may be either above atmospheric pressure or absolute pressure depending upon the



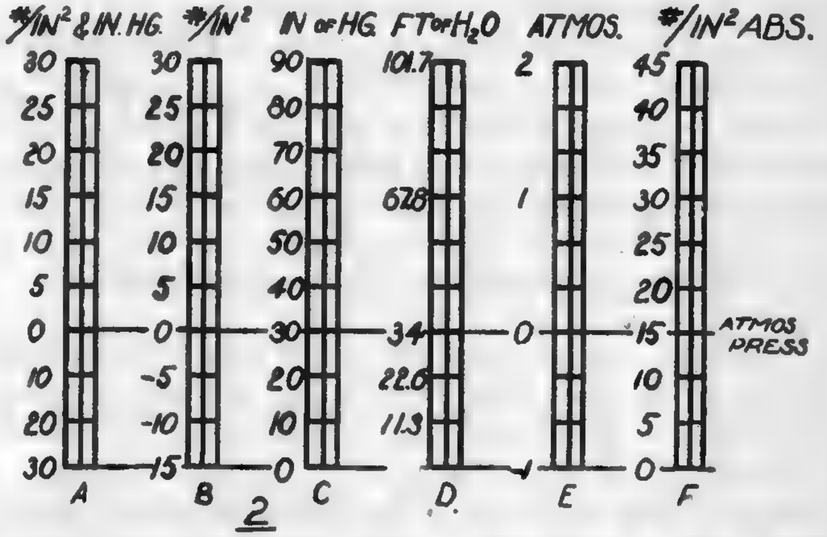


Fig. 5. The standard pressure scales and the different ways of registering atmospheric pressure

1. A simple mercury barometer is shown at (A). The compound gauge (B) is calibrated in inches of mercury for pressures below atmospheric, and in pounds per square inch gauge for pressures above atmospheric. The water column (C) illustrates the water equivalent of the mercury barometer
2. This illustrates pressures of from 0 pounds per square inch to 30 pounds per square inch gauge expressed in common units. It may be noticed that all values, reading horizontally, ■■ equal. The apparent difference in readings ■ due to the scale used

construction of the gauge. Mercury is usually used for measuring pressures below atmospheric pressure and water for *small pressures* above. (Gas lines, etc.)

The barometer, Figure 5, is an example of a mercury gauge. With a vacuum in one end of the tube, it is found that the atmospheric pressure will support a mercury column 29.92" in height.

9. BOYLE'S LAW—For Gases:

There is a very interesting relation between the pressure and volume of a gas called Boyle's law. It is stated as follows:

"The volume of a gas varies inversely as the pressure provided the temperature remains constant."

Therefore, if a certain quantity of gas has its pressure doubled, the volume becomes one-half that of the original. Or, if the volume becomes doubled, the gas has its pressure reduced by one-half. If a perfect gas is considered, Boyle's Law may be expressed as a formula:

$$\text{Pressure} \times \text{Volume} = \text{A constant number.}$$

This being true, one can say that when either the pressure or the volume is changed, the corresponding pressure or volume is changed in the opposite direction. Therefore, Old Pressure $\times$ Old Volume = the New Pressure $\times$ the New Volume. This formula will hold true only if the pressures are expressed as absolute pressures. Expressed in letter form:

$$P_O \times V_O = P_N \times V_N$$

Example:

What is the new volume, if 5 cubic feet of gas at 20 pounds per square inch gauge were compressed to 60 pounds per square inch gauge providing the temperature remained constant? Consider atmospheric pressure = 15 pounds per square inch.

$$P_O \times V_O = P_N \times V_N$$

$P_O = 20$ pounds per sq. in. gauge $= 35$ pounds per sq. in. abs.
$P_N = 60$ pounds per sq. in. gauge $= 75$ pounds per sq. in. abs.

$$35 \times 5 = 75 \times V$$

$$\frac{35 \times 5}{75} = V_N$$

$$\frac{35}{15} = V_N$$

$$\frac{7}{3} = V_N$$

2.33 cubic feet $= V_N =$ New Volume

10. DALTON'S LAW:

Dalton's law of partial pressures is the foundation of the principle of operation of one of the absorption type refrigerators. The law may be stated as follows:

"The total pressure of a mixture of gases is the sum of the partial pressures of each of the gases in the mixture." The total pressure of the air is the sum of the oxygen, the nitrogen, the carbon dioxide, and the water vapor pressure.

11. WORK AND POWER:

A complete study of energy relations is also necessary to a complete understanding of refrigeration. *Energy* is described as "*the capacity to do work*," where *work* is defined as "*force multiplied by distance through which it travels.*" The unit of work is called the foot-pound. One foot-pound is the amount of work done in lifting a one pound weight a vertical

distance of one foot. Work is sometimes expressed in inch-pounds. In this case, the distance through which the force acts is measured in inches.

Example: Calculate the work done in foot-pounds in lifting a weight of 2000 pounds a vertical distance of 10 feet.

$$\text{Work} = \text{Force} \times \text{Distance}$$
$$= 2000 \times 10 = 20{,}000 \text{ foot-pounds}$$

or expressed in inch units

$$2000 \times 10 \times 12 = 240{,}000 \text{ inch-pounds}$$

Power is defined as the time rate of doing work. The common unit of mechanical power is the horsepower and is the equivalent of 33,000 foot-pounds of work per minute. If in the above problem the 2000-pound weight is lifted 10 feet in 2 minutes, the power required would be:

$$\text{Horsepower} = \frac{\text{Weight} \times \text{Distance}}{\text{time} \times 33{,}000} \text{ or}$$

$$\text{Horsepower required} = \frac{2{,}000 \times 10}{2 \times 33{,}000} = .3 \text{ Horsepower}$$

12. HEAT ENERGY AND CONVERSION FACTORS FOR HEAT; ELECTRICAL AND MECHANICAL ENERGY:

Energy exists in other forms than the mechanical, i.e.; there is electrical energy and heat energy.

The study of refrigeration deals mainly with heat energy, but it must be understood that the heat energy is usually produced by utilizing a combination of electrical and mechanical energy. There is a relation that exists between these three forms of energy. This relationship may be expressed as follows:

778 foot-pounds = 1 British Thermal unit (B. T. U.)

1 Horsepower (H. P.) = 2545.6 British Thermal units per hour.

746 Watts = 1 Horsepower

Heat is believed to be the motion of the molecules of a substance or is the internal friction produced in these molecules. The theory is that temperature is an indication of the speed of molecular motion. The number of molecules moving in the mass of a substance means quantity of heat, but the speed at which they travel is their temperature or heat level. Therefore, the British Thermal unit is the measurement of heat quantity, and temperature is the measurement of speed of travel of each molecule.

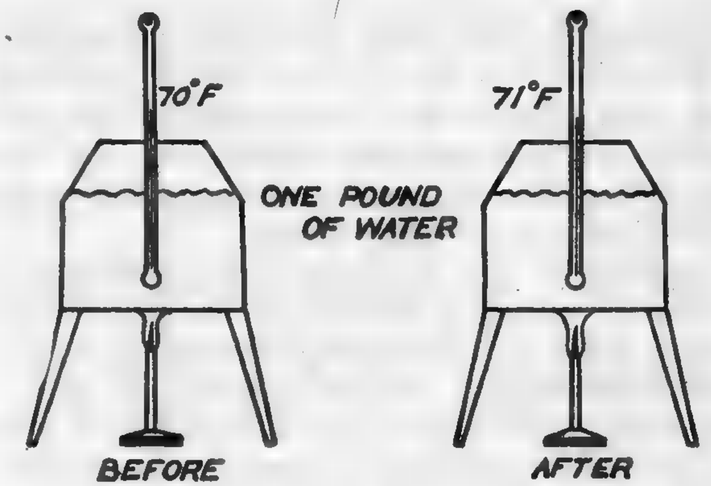


Fig. 6. A simple experiment to demonstrate the addition of one British Thermal unit of heat. One pound of water is heated 1° Fahrenheit

The heat unit, B. T. U., represents the words "British Thermal unit" and is defined as the amount of heat required to raise the temperature of a pound of water one degree Fahrenheit. Figure 6. Temperature and temperature scales are explained in the following paragraphs.

13. TEMPERATURE:

Temperature is defined as the heat intensity or heat level of a substance. Temperature alone does not give the amount

of heat in a substance, but it is an indication of the degree of warmth, or how hot the body is.

Example: A small copper dish heated to 1340°F. does not contain as much heat as 5 pounds of copper heated to 300°F. but it is warmer. That is, its heat level is higher or its intensity of heat is greater, but it does not contain so much heat.

14. TEMPERATURE SCALES:

The methods and scales used to measure temperatures have been arbitrarily chosen by scientists, and the following standards have been established. The common British and American scales are the Fahrenheit scale and the Fahrenheit absolute scale, while the metric system embodies the Centigrade and Centigrade absolute scales.

The Fahrenheit scale is so fixed that it divides the heat level from the melting temperature of ice to the boiling temperature of water into 180 equal divisions and sets the melting of ice at 32 divisions above the zero on the scale. Therefore, ice melts at 32°F. and water boils at 212°F. (180°F. + 32°F.) assuming standard atmospheric pressures. The Fahrenheit absolute (F_A) scale is a scale using the same divisions as the Fahrenheit scale but setting the zero of the scale at that temperature where molecular action of all substances ceases, i. e., where no more heat exists in the body and the temperature cannot be lowered any farther. This temperature corresponds to −460°F. and water boils at 672°F_A assuming standard atmospheric pressure.

The Centigrade scale has coarser divisions than the Fahrenheit scale and the zero (0°) of this scale is set at the melting temperature of ice. The boiling point of water is fixed 100 divisions above that point or 100°C. assuming atmospheric pressure.

The reader may wonder why the melting temperature of ice and the boiling temperature of water were taken as standards. This is because water has a very constant freezing and boiling-point temperature. Figure 7.

Occasionally one is called upon to convert a temperature registered in Fahrenheit degrees to Centigrade degrees or conversely. For this purpose formulae have been developed, based upon the fact that Fahrenheit zero is located 32° below the Centigrade zero and the distance between the freezing-point of water and the boiling-point of water is 180° on the Fahrenheit scale and 100° on the Centigrade scale.

To convert Centigrade degrees into Fahrenheit degrees:

$$°F. = 9/5°C. + 32$$

To convert Fahrenheit degrees into Centigrade degrees:

$$°C. = 5/9\ (°F. - 32)$$

To convert Fahrenheit degrees to Fahrenheit absolute:

$$°F_A = °F. + 460$$

To convert Centigrade degrees into Centigrade absolute:

$$°C_A = °C. + 273$$

Example:

Convert 50°F. into ° Centigrade

$$C. = 5/9\ (F. - 32)$$
$$C. = 5/9\ (50 - 32)$$
$$C. = 5/9 \times 18$$
$$C. = \frac{5 \times 18}{9} = \frac{90}{9} = 10°$$

Convert 75°C. into ° Fahrenheit

$$F. = 9/5\ C. + 32$$
$$F. = 9/5 \times 75 + 32$$
$$F. = \frac{9 \times 75}{5} + 32$$

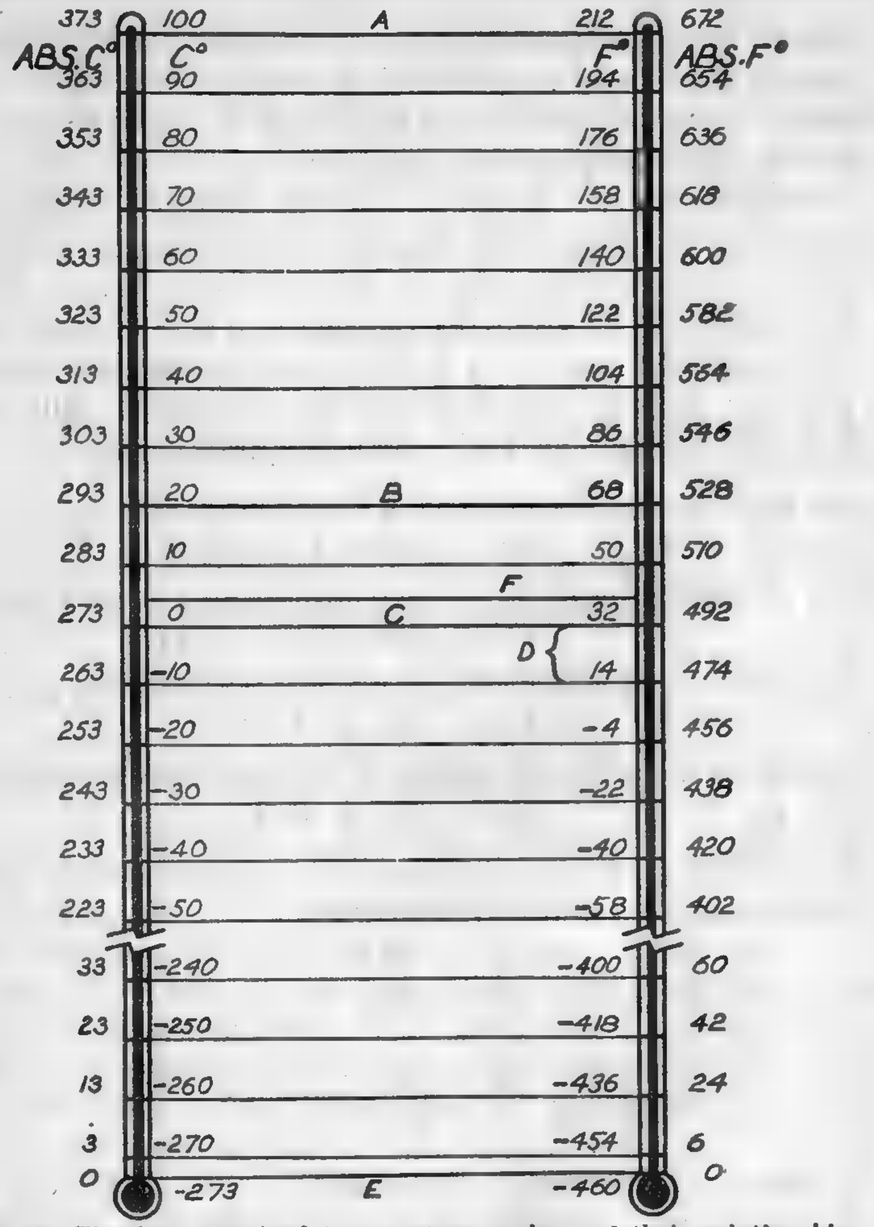


Fig. 7. The four standard temperature scales and their relationship A. Boiling temperature of water at atmospheric pressure; B. Average room temperature; C. Freezing temperature of water at atmospheric pressure; D. Cooling unit temperature range; E. Absolute zero temperature; F. Average refrigerator box temperature

$$F. = 9 \times 15 + 32$$
$$F. = 135 + 32$$
$$F. = 167°$$

Convert — 5°F. into °C.

$$C. = 5/9\ (F. - 32)$$
$$C. = 5/9\ (-5 - 32)$$
$$C. = 5/9 \times -37$$
$$C. = \frac{5 \times -37}{9} = \frac{185}{9} = -20\ 5/9°$$

15. CHARLES' LAW:

Gases behave consistently with temperature changes; this is stated in Charles' Law. "At a constant pressure the volume of a gas varies directly as the absolute temperature; and at a constant volume, the pressure varies directly as the absolute temperature. In the equation form: At constant volume,

The Old Pressure × the New Absolute Temperature =
The New Pressure × the Old Absolute Temperature

$$P_O \times T_N = P_N \times T$$
$$T = \text{Absolute Temperature}$$

At constant pressure

the Old Volume × the New Absolute Temperature =
the New Volume × the Old Absolute Temperature

$$V_O \times T_N = V_N \times T_O$$

Example: What is the pressure of a quantity of confined gas when raised to 60°F. if its original pressure was 10 pounds per square inch abs. and temperature 40°F.?

Answer: Constant Volume.

$$10 \times (60+460) = X \times (40+460)$$

$$\frac{10 \text{ pounds}}{X} = \frac{500°}{520°}$$

$$500\ X = 5200$$

$$X = 10.4 \text{ pounds per square inch abs.}$$

Example: A 5 cubic feet volume of gas at 37°F. is raised to 90°F. at constant pressure. What is the new volume?

Answer: $5 \times (90 + 460) = X \times (460 + 37)$

$$\frac{5}{X} = \frac{497}{550}$$

$$X = \frac{5 \times 550}{497} = 5.54 \text{ cubic feet}$$

16. GAS LAW:

Boyle's Law and Charles' Law may be combined to solve true gas problems and the formula is as follows:

$$\frac{P_O \times V_O}{T_O} = \frac{P_N \times V_N}{T_N}$$

P_O, V_O, and T_O represent original conditions.
P_N, V_N, and T_N represent new conditions.

Absolute values for temperature and pressure must be used in this equation.

A more concrete equation is: $PV = WRT$
Where P = Pressure in pounds per square foot abs.
V = Volume in cubic feet R = Gas Constant
W = Weight of the gas in pounds
T = Absolute Temperature °F.

This equation is useful for many pressure-volume problems and its use is easily followed.

R = Gas constant and it must be known for the gas under consideration. Figure 8.

17. SENSIBLE AND LATENT HEAT:

A physical phenomenon of all pure substances is their ability to change their state, such as solid to liquid and liquid to gaseous. These changes of state occur at the same tempera-

TABLE OF GAS VALUES

	Specific Heat		R
	Cp	Cv	
Air	.24	.17	53.34
Ammonia	.51	.35	123.24
Sulphur dioxide	.154	.123	24.14
Carbon dioxide	.22	.17	38.82
Ether	.48	.45	23.11
Oxygen	.22	.16	48.55
Alcohol	.45	.40	41.55
Water vapor	.480	.37	83.23

Fig. 8. A table of gas values

ture and pressure combination for any one substance. Since it takes heat to produce these phenomena, a classification must be made of the different kinds of heats. Therefore we call that heat which causes a *change of temperature* in a substance, *sensible heat*, and that heat which brings about a *change of state*, *latent* (hidden) *heat*. The difference between these two heats should be kept very clearly in mind because all the following explanations of the refrigeration cycle are based upon these two heats, *sensible* and *latent*. There are two latent heats for each substance, solid to liquid

heat (melting and freezing) and liquid to gaseous (vaporizing and condensing). Figure 9. These are called the latent heat of fusion and the latent heat of vaporization respectively.

18. SPECIFIC HEAT:

The sensible heat required to cause a temperature change in substances varies with the kind of substance and the amount

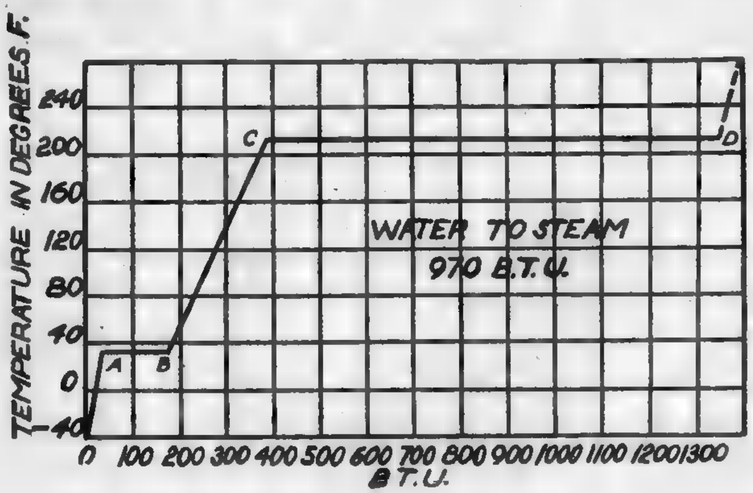


Fig. 9. A graph of the three states of water and the heat required to effect the change at atmospheric pressure
From —40 F. to A, 86 B.T.U. were added to the one pound of ice, raising its temperature to +32° F.
From A to B, 144 B.T.U. were added to melt the ice. Note that the temperature did not change
From B to C, 180 B.T.U. were added and the temperature of the water was changed to 212° F.
From C to D, 970 B.T.U. were required to change the water to steam at 212° F.

of the substance. That is, different substances require different amounts of heat per unit quantity of the substance to effect these changes of temperature, and therefore a student of these properties must establish a standard of heat absorption ability for each substance. This ability or property

is called the specific heat of the substance and is the amount of heat required to raise 1 pound of the substance 1° F. This value is good for computations which involve no changes of state because if this should occur, the specific heat of the substance changes also. To determine the amount of heat necessary to cause a change of temperature in a substance multiply the weight of the substance by the specific heat and by the temperature change provided there is no change of state. Figure 10.

SPECIFIC HEAT OF COMMON SUBSTANCES

Material	Specific Heat (B.T.U. #)
Wood	.327
Water	1
Ice	.504
Iron	.129
Mercury	.0333
Alcohol	.615
Copper	.095
Sulphur	.177
Glass	.187
Graphite	.200
Brick	.200
Glycerine	.576
Liquid ammonia at 40° F	1.1
Carbon dioxide at 40° F	.6
Methyl chloride at 40° F	.38
Sulphur dioxide at 40° F	.35

Fig. 10. Some specific heat values

Specific heat problems are easily solved by the use of the following formula:

British Thermal units = sp. ht. × wt. × the temp. change in degrees F.

19. APPLICATION OF LATENT HEAT:

In refrigeration work, the physics of latent heat is of special importance because it is this heat which gives us our cold or

freezing temperatures. When ice melts *its temperature remains constant;* nevertheless it absorbs a considerable amount of heat changing from ice to water. When a substance passes from a liquid to a gas as in a mechanical refrigerator, its heat absorption is very high and advantage is taken of this fact in designing the refrigerator.

Every substance has a different latent heat value to bring about a change of state for both liquid-solid and liquid-gaseous states. Latent heats for water and the more common refrigerants are as follows (Figure 11):

LATENT HEAT OF WATER AND COMMON REFRIGERANTS

Material	Melting	Vaporizing
Water	144	970.4 (at 212° F.)
Ammonia	...	565.0 (at 5° F.)
Sulphur dioxide	...	169.38 (at 5° F.)
Methyl chloride	...	178.5 (at 5° F.)
Freon (F-12)	...	69.5 (at 5° F.)
Carrene (methylene chloride)	...	162.0 (at 5° F.)

Fig. 11. Some latent heat values

20. REVIEW PROBLEMS ON HEAT:

The answers to these problems will be found on page 804.

1. Convert 78°F. to °C.
2. Convert 20°C. to °F.
3. Convert 5°F. to °C.
4. Convert 432°F_A to °F.
5. Convert 14°F. to °C_A
6. What is the equivalent of 20 kilowatts in
   (*a*) British Thermal units?
   (*b*) Foot-pounds?
7. What is the new volume of 50 cubic feet of gas if the pressure changes from 35 pounds per square inch gauge to 85 pounds per square inch gauge?
8. How many British Thermal units must be extracted to cool 10 pounds of iron from 70°F. to 10°F.?
9. How many British Thermal units must be removed from a cooling unit to cool it from 85°F. to 15°F., if it contains 10 pounds of copper and 20 pounds of glycerine?
10. Calculate the number of British Thermal units required to convert 1 pound of ice at 0°F. to steam at 212°F.

21. PHYSICS OF REFRIGERATION:

Heat and cold are opposite ends of the same thing. Heat is technically defined as the rate of vibration of the molecules in the substance, while cold is labeled as the absence of heat. It may be pointed out here that heat cannot travel from a cold body to a hot body, but always travels from the body of a higher temperature to a colder one. (Second law of Thermodynamics.)

22. HEAT TRANSFER:

The movement of heat may be by any one of three methods, or by a combination of any two or of all three of these methods as follows:

CONDUCTION:

Conduction is the flow of heat from one part of a substance to another part of the same substance, or from one substance to another substance in direct contact with it. A piece of iron with one end placed in a fire will soon become warm from end to end. This is an example of the transfer of heat by conduction. The heat travels through the iron using the iron as the conducting medium. The substances which have a very small conducting value are called insulators. See Paragraph 441.

24. CONVECTION:

Convection is the conveying of heat from one point to another by the movement of some easily circulated medium such as air. A common example of this is the movement of heat-laden air from a furnace into the rooms of a house where it releases its heat and then returns through the cold air duct to receive another supply of heat from the furnace.

25. RADIATION:

Radiation is the transfer of heat by heat rays. Examples of this are the heat from the sun and the heat felt near a flame. It should be understood that heat rays do not heat the air through which they pass. They heat only the surfaces which they strike.

26. CONTROL OF HEAT FLOW:

The flow of heat by each of these methods can be controlled. That is, the transfer of heat by each of these methods can be aided or impeded exactly according to the particular need. Conduction may be aided by providing large conducting surfaces and good conducting materials. Cork, wood, mineral wool, and many other similar materials are poor conductors of heat. Poor conductors of heat are often referred to as *heat insulators*.

Convection may be aided by speeding the flow of the conveying medium, for example, forced-air circulation heating systems. Conversely, it can be impeded by retarding the flow of circulation.

Radiation, or rather the transfer of heat by radiation, may be aided by making the radiating surfaces of a material or of a color known to be a good radiator of heat and, by making the receiving surfaces of a material or color known to be a good absorber (or poor reflector) of radiated heat. Conversely, it may be impeded by reversing this application. Dark materials or colors absorb and radiate readily. Light-colored or shiny materials have the opposite properties.

27. ICE:

Because ice has played such an important part in the refrigeration industry, a few important facts concerning it follow:

As stated before, ice changes to water at 32°F. at atmospheric pressure, and the water changes to steam at 212°F.

The heat absorption ability of ice when changing from a temperature below 32°F. to 32°F. is .504 British Thermal units per pound per degree change in temperature, and when changing from ice to water at 32°F. is 144 British Thermal units for 1 pound of ice changing to 1 pound of water. That is,

The specific heat of ice = .504 B. T. U. per pound
The latent heat of fusion of ice = 144 B. T. U. per pound
The specific heat of water = 1 B. T. U. per pound
The latent heat of vaporization of water = 970.4 B. T. U. per pound

Example: How many B. T. U. will 25 pounds of ice at 5°F. absorb in changing to liquid at 40°F.?

From ice at 5°F. to ice at 32°F.

$.504 \times 25 \times (32 - 5)$

$.504 \times 25 \times 27 = 341.2$ British Thermal units

From ice to water at 32°F.

$144 \times 25 = 3600$ British Thermal units

From water at 32°F. to water at 40°F.

$1 \times 25 \times (40 - 32)$

$1 \times 25 \times 8 = 200$ British Thermal units

341.2
3600
200
Total 4141.2 British Thermal units

28. ICE AND SALT MIXTURES:

Refrigerating by ice will not give continuous refrigeration temperatures below 40°F.; therefore to obtain lower temperatures that are required in some instances, ice and salt mixtures are used. These mixtures, ice and salt (NaCl) and ice and calcium chloride (CaCl) lower the melting temperature of ice. That is, an ice and salt mixture may be made which will melt at 0°F.

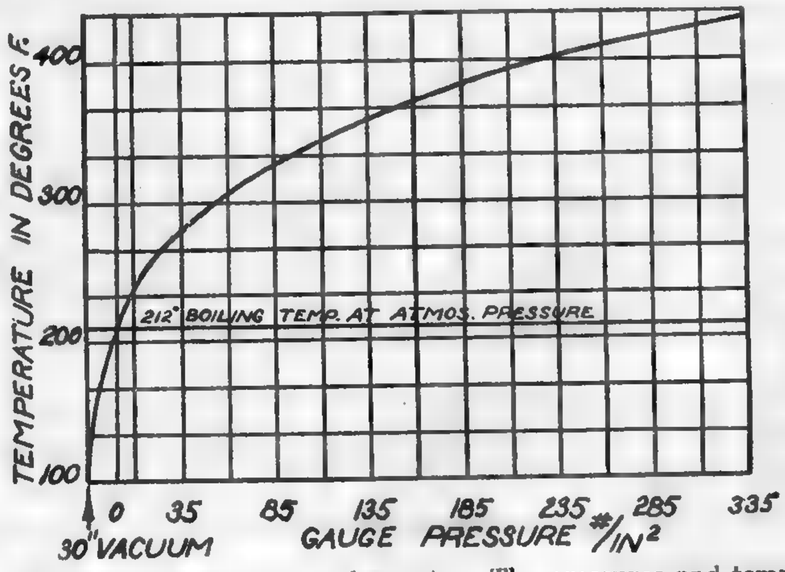


Fig. 12. The vapor pressure curve for water. The pressures and temperatures required to permit a change from water to steam or vice versa

29. EFFECT OF PRESSURE ON EVAPORATING TEMPERATURES:

The boiling temperature for any liquid depends upon the pressure under which the liquid is placed. Water normally boils at 212°F., but if the pressure on the surface of the water is increased to 100 pounds per square inch gauge, the boiling-point will be raised to 338°F. If instead of increasing the pressure it is decreased to an absolute pressure of 3 pounds per square inch, the water will boil at 142°F. Figure 12.

It is the effect of reduced pressure on the boiling temperature of certain liquids that makes the operation of the domestic refrigerator possible. As an illustration of this, sulphur dioxide boils at 14°F. under atmospheric pressure while at 8 inches of vacuum the boiling temperature is 5°F. See Figure 309 for a graph of the temperature characteristics of sulphur dioxide.

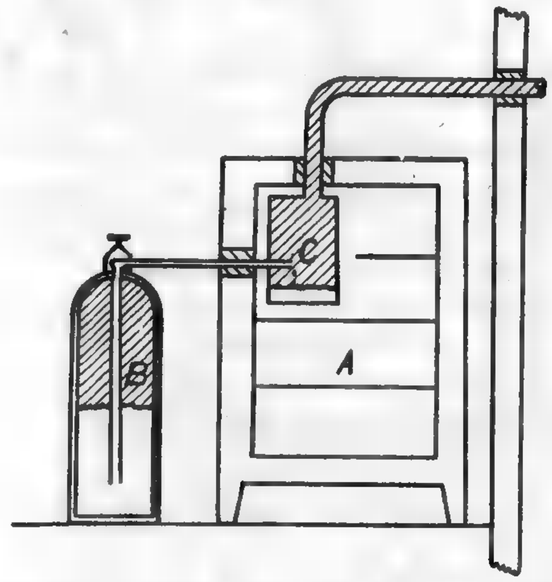


Fig. 13. An elementary refrigerator using ammonia (not practicable) A. The refrigerator box; B. The ammonia tank in which the ammonia is stored under a high pressure; C. The cooling unit where the ammonia is changed from a liquid to a gas at atmospheric pressure and absorbs a considerable amount of heat

30. THE ELEMENTARY REFRIGERATOR:

The operation of the domestic electric refrigerator is based on the heat absorption property of a fluid passing from the liquid to the gaseous state. That is, if one were to put a container of fluid that had a low boiling temperature into an ice-box

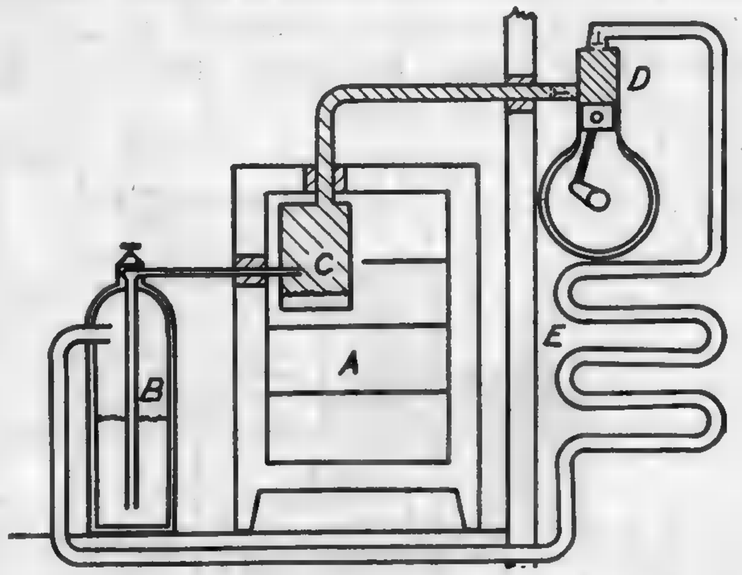


Fig. 14. An elementary mechanical refrigerator
A. The refrigerator box; B. The storage tank for the liquid ammonia; C. The cooling unit where the ammonia vaporizes and absorbs considerable heat; D. The compressor which takes the vaporized ammonia from the cooling unit and compresses it to a high pressure and releases it to the condenser; E. The condenser where the compressed ammonia is cooled and the latent heat removed allowing it to condense and pass to the storage tank as a liquid.

and vent the gas to the outside, he would have a heat absorber in the box. Figure 13. The liquid can boil only at its evaporation temperature, say 20°F., and this liquid will be at this temperature until it has completely evaporated. If one tried to raise its temperature by adding heat, the only result would be a more rapid evaporation of the liquid into

a gas, provided the pressure remained constant. Being at this low temperature there is, of course, a transfer of heat to it from the surrounding objects. This heat helps the evaporating and the heat is carried away in the vapor passing off. Thus, the fluid changing its state gets the energy (or heat) for doing this from the objects surrounding it and that heat is removed in the vapor to the outside of the box.

This type of refrigerator works very nicely, but it is a very expensive method because the refrigerant fluid is lost. However, in the domestic refrigerator this escaping vapor is captured, compressed, and cooled to a liquid state again so that it can be used over and over. Figure 14.

The above gas needs to be compressed again before it will return to the liquid form. This is because in order to recondense the vaporized refrigerant, the vapor must be compressed to a pressure corresponding to a boiling-point that is higher than the maximum room temperature in which the refrigerator is to operate in order that the latent heat of vaporization may be radiated to the room. The temperature at which a refrigerator cooling unit is kept depends only upon the pressure at which the refrigerant is evaporated, while the amount of heat removed depends only upon the amount of refrigerant changed into a gas.

31. REFRIGERATION UNITS:

In order to compare different refrigerators and machines, they are rated by two different standards. The engineering standard is the British Thermal unit per twenty-four hours absorption rating, and the box standard is *the cubic foot capacity of the refrigerator boxes*, i. e., 4 cubic feet, 5 cubic feet, 6 cubic feet, 7 cubic feet, 8 cubic feet, etc.

One may also compare them on the basis of the size of the electric motor required to drive them.

The engineering standard applies to all refrigerating machines, including domestic and commercial installations, and is on a basis of a one ton machine. That is, all the refrigeration mechanisms are compared to the standard 288,000 British Thermal units per twenty-four hours machine. The refrigeration capacity of this machine is equivalent to the melting of 2000 pounds of ice during twenty-four hours. The computing of the size of the unit must be done using 5°F. as the evaporating temperature and 86°F. as the condensing temperature.

Foods containing fruit juices or sugar, or both, will have a freezing temperature considerably below 32°F. depending upon their exact compositions.

Domestic machines should be equipped with a low temperature compartment in which it is possible to reach a low temperature of 15-20°F. for freezing desserts.

32. SOLID CARBON DIOXIDE (DRY ICE) (ZERO ICE):

Solid carbon dioxide is often used for refrigeration. It is a white crystalline substance formed by allowing liquid carbon dioxide to escape into a snow chamber. The heat for vaporizing the liquid is drawn from the interior of the chamber so that a very low temperature, —109°F., is formed, with the result that quantities of the carbon dioxide solidify. This solid is pressed into various shapes and sizes and sold for refrigeration purposes under such names as dry ice, zero ice, etc. It remains at a temperature of —109°F. and sublimes, that is, it goes directly from the solid to the vapor state without becoming a liquid. It has some very desirable characteristics in that it does not wet the surfaces that it touches, and the gas given off is a preservative. The very low temperature maintained permits handling frozen goods without an expensive insulated container. It is used a great deal by ice cream vendors and the like.

The latent heat of sublimation is 248 B.T.U. per pound. The heat absorbed by the vapor in passing from —109°F. to 32°F. is approximately 27 B.T.U. per pound. This added to the latent heat of sublimation makes a total heat-absorbing capacity of 275 B.T.U. per pound. This is a greater heat-absorbing value than for water ice. Dry ice is generally more expensive per pound than water ice.

33. CRITICAL TEMPERATURE:

The critical temperature of a substance is the maximum temperature at which the substance may be liquefied, regardless of the pressure applied upon it. Refer to the table, Figure 308, for the list of critical temperatures for refrigerants. The condensing temperature for all refrigerants must be kept below the critical temperature for the refrigerant used, otherwise the refrigerator would not operate. The lowest critical temperature for common refrigerants is for *carbon dioxide* and is at 87.8°F. This refrigerant could not be used in air-cooled condensers.

It is well to keep in mind during the ensuing chapters that the average correct refrigerating temperature for domestic refrigerators is about 45° F. and to make ice, a temperature lower than 32°F. is needed.

34. REVIEW PROBLEMS AND QUESTIONS:

The answers to these problems and questions will be found on page 804.

1. What is the absolute pressure equivalent in pounds per square inch of 8 inches of mercury vacuum?
2. What is the gas space in the cylinder of a compressor if it has a 2-inch bore and a 3-inch stroke?

3. If 100 cubic inches of a gas at 15 pounds per square inch gauge were compressed to 20 cubic inches, what is the gauge pressure if the temperature remains constant?
4. If 100 cubic inches of gas under constant pressure were changed from 40°F. to 290°F., what is the new volume?
5. How many B.T.U.'s will be required to change 5 pounds of ice at 32°F. into water at 82°F.?
6. How many pounds of sulphur dioxide must be evaporated at 5°F. to change 50 pounds of water from 72°F. to ice at 5°F. if the container for the water is made of copper and weighs 3 pounds?
7. If 2 cubic feet of gas at 90°F. and under ■ pressure of 15 pounds per square inch gauge are changed to 4 cubic feet at 40°F., what is the new gauge pressure?
8. What is the pressure difference between 6 inches of mercury vacuum and 8 pounds per square inch gauge?
9. If ■ 15-pound weight is placed on an area 2 by 3 inches, what is the pressure in pounds per square inch absolute?
10. If the head pressure is 85 pounds per square inch gauge, what is the total force on one face of ■ circular disk 5 inches in diameter?
11. What is the average temperature desired in ■ domestic cabinet?
12. What determines the temperature at which a refrigerant will vaporize?
13. Express standard atmospheric pressure in pounds per square foot.
14. Should refrigerants be operated at temperatures above or below their critical temperature?
15. What is dry ice?
16. Should dry ice ever be put in a sealed container? Why?
17. What is the relative heat absorbing value of 1 pound of dry ice as compared to 1 pound of water ice?

18. Does color affect the amount of heat absorbed by ■ surface by radiation? How?
19. Name ■ condition which illustrates the principle of convection.
20. Which material conducts heat the fastest, glass or copper?

CHAPTER II

THE COMPRESSION SYSTEM

35. LAWS OF REFRIGERATION:

All refrigerating mechanisms are designed and built around four basic thermal laws:

1. Fluids absorb heat while changing from a liquid state to a gaseous state and give up heat in changing from a gas to a liquid.
2. The temperature at which a change of state occurs is constant during the change, but this temperature will vary directly with the pressure.
3. Heat will flow only from a body at a certain temperature to a body at a lower temperature.
4. In selecting metallic parts of the cooling and condensing units, metals are selected which have a high heat conductivity.

36. THE COMPRESSION CYCLE:

All compression systems of refrigeration operate upon a refrigerant sealed in an air-tight and absolutely leak-proof mechanism. This means that in working they repeat over and over the freezing and cooling operations. The process of repetition of a similar order of things is called a cycle. Therefore, all our refrigerators operate on what is called a cycle, meaning a course of events which has a tendency to repeat in the same order.

In mechanical refrigeration only two different cycles have been developed. The older and still more popular cycle uses a mechanical compressor of some sort to compress the gases. The newer type is called the absorption type and

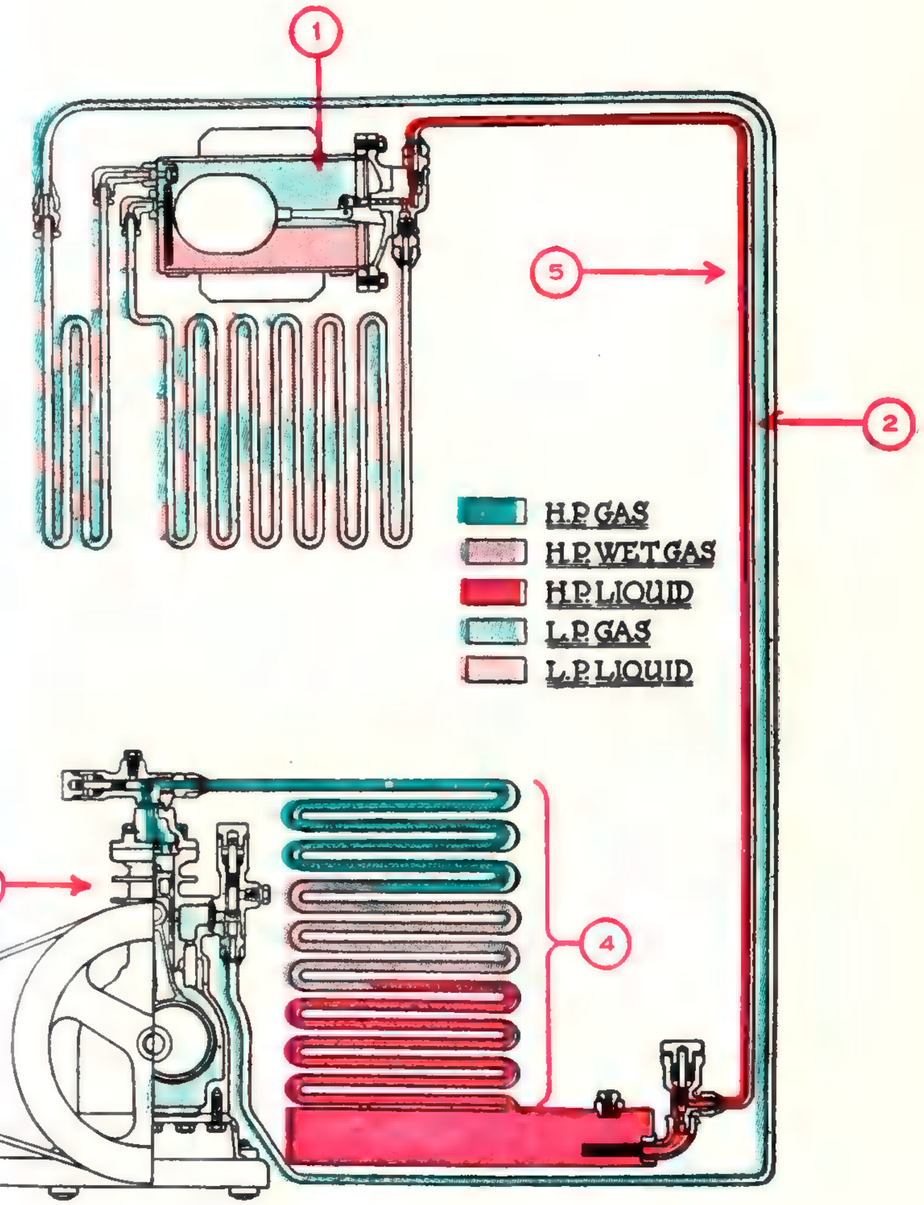


Fig. 16. A compression cycle using a low pressure side float valve
(Courtesy of: Electrolux Refrigerator Sales, Incorporated)

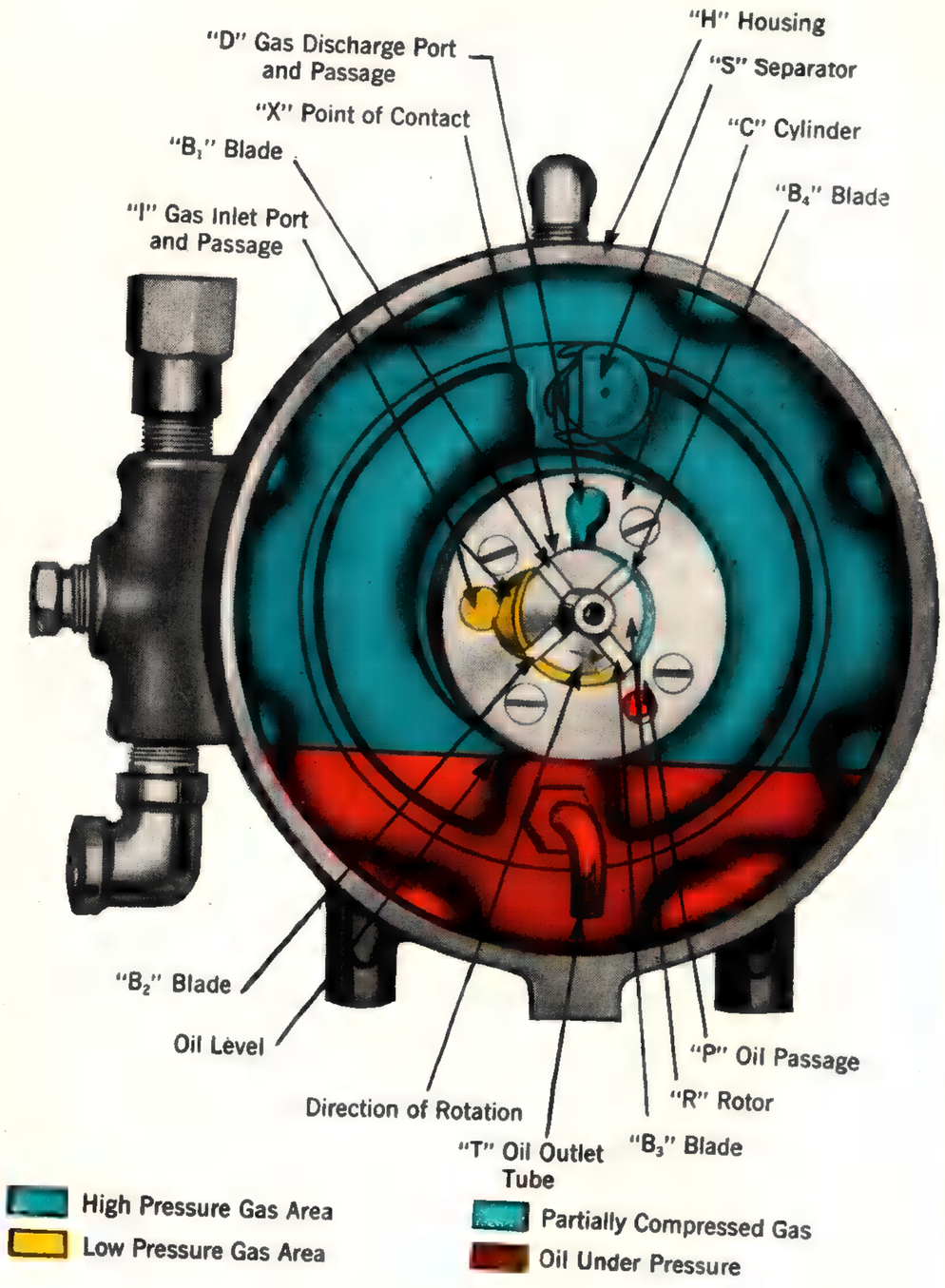


Fig. 18. A rotary type compressor with four blades mounted in the rotor *(Courtesy of: Sunbeam Electric Manufacturing Company)* .

works on the principle of temperature and pressure changes resulting from heat applications.

Only a thorough and careful study of the cycles will enable a student to master the refrigeration field. The two following chapters endeavor to give a very detailed description and discussion of the above cycles.

The compressor cycle is called by that name because it is the compressor which enables a transfer of energy. It is by

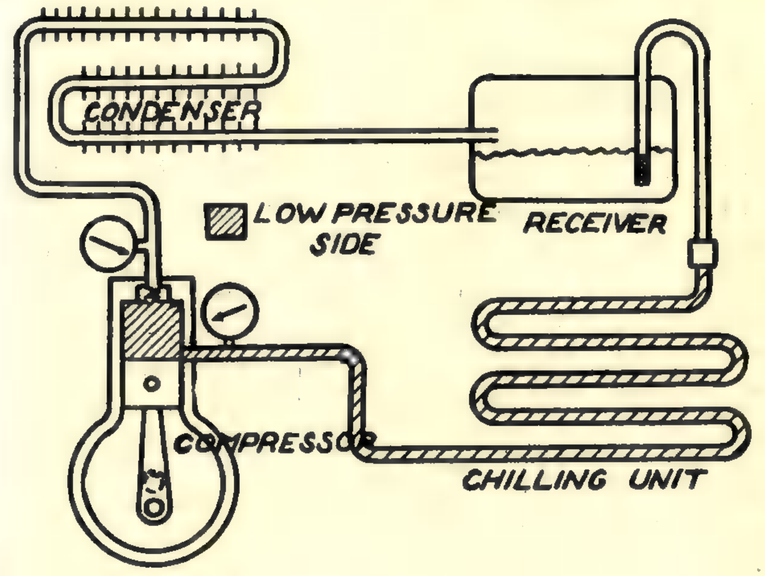


Fig. 15. A compression cycle showing the two pressure conditions

means of the compressor that the refrigerant is able to absorb heat in one place and discard it in another. In other words, the compressor is that part of the mechanism used to put the heat-laden refrigerant in such a condition that it may dissipate the heat energy it absorbed when evaporating at low pressure.

The fundamental cycle for a refrigerating apparatus consists principally of a high pressure side and a low pressure side. Figure 15.

The operation of the apparatus is to transfer heat from a certain place to another place, i. e., from the inside of an ice-box to the outside air, and from the water of a water cooler to the outside air. It may be compared to a sponge picking up water in one place and releasing it in another by pressing it. To have a transfer of heat there must be a temperature difference and to get the temperature differences there must be a high pressure side (dissipators) and a low pressure side (absorbers).

37. THE OPERATION OF THE COMPRESSION CYCLE:

Basically (Figure 16), the liquid evaporates in the cooling unit (1) under a low pressure. The pressure will vary in popular refrigerators between 10 inches of vacuum and 5 pounds of pressure. This allows the evaporation (absorbing of latent heat) to take place at a low temperature, because, as the pressure decreases, the boiling or evaporating temperature also falls. This heat-laden gas is then drawn through the suction line (2) to the compressor (3) which compresses and discharges it into the condenser (4) where it cools and gives up its latent heat of evaporation under a high pressure. Then it returns to a liquid and settles to the liquid receiver tank. The liquid line (5) carries the liquid refrigerant to the cooling unit where it evaporates and absorbs heat (1) and the suction line (2) carries the gas back to the condensing unit. The following parts are necessary in a refrigeration cycle:

High Pressure Side	Compressor—driven by a motor
	Condenser—heat dissipator
	Receiver—storage tank
	Liquid line

Low Pressure Side	Refrigerant control
	Cooling unit—heat absorber
	Motor control
	Suction line

The refrigerant control and motor control listed above are used to obtain automatic operation.

38. A TYPICAL COMPRESSION CYCLE:

In detail, the cycle operates as follows: The vapors are compressed in the compressor and passed to the condenser. During compression the pressure increases (due to Boyle's Law), and the temperature increases (explained by Charles' Law) until the gas temperature is greater than the temperature of the condenser cooling medium (usually air). Heat will now flow from this gas to the cooling medium, allowing the gaseous refrigerant to return to the liquid state. After condensing (liquefying) the liquid refrigerant is stored in the liquid receiver until needed. From the liquid receiver it passes through the high pressure liquid line to the expansion valve (dry system), or to the float needle valve (flooded system), where the pressure is reduced to a pressure at which the liquid will evaporate at a temperature of 5°F. to 10°F. In evaporating the liquid in the cooling unit, considerable heat is absorbed and refrigeration furnished. After expansion and evaporation in the evaporator or cooling unit, the gas is drawn back to the low side of the compressor through the suction line. It passes through the intake valve of the compressor into the cylinder; here it is compressed and discharged through the exhaust valve into the high pressure side where the heat absorbed in the cooling unit is radiated. This causes the re-

frigerant to recondense and it is stored in readiness for a repetition of the cycle just described.

39. TYPES OF COMPRESSORS:

There are several different kinds of compressors:

The piston-cylinder type	Figure 17
The rotating pump type	Figure 18
The gear pump type	Figure 19
The centrifugal type	

40. RECIPROCATING COMPRESSORS:

The reciprocating or piston type compressor is the most common type in use. Referring to Figure 17, it may be seen that this compressor consists of a cylinder, crank shaft, piston, connecting rod, cylinder head, intake and exhaust valves, servicing valves, flywheel, crankshaft seal, gaskets, and oil. It is a very efficient type of compressor. Its construction resembles in many ways that of the automobile engine. The cylinders and cylinder heads are made of a fine grade of cast iron or cast steel and the piston is made of a similar material. The connecting rods and crank shaft are usually drop forged steel, although some of them are made of cast iron, and bronze connecting rods have been used. Crank shafts are usually made of steel and are case hardened. Quite often these compressors use the eccentric type of crank shaft, in which case the eccentrics are made of cast iron as are also the connecting rods. An eccentric type crankshaft is permissible in a refrigerating compressor because of the low bearing loads encountered. This eccentric construction reduces the vibration of the compressor when running, inasmuch as the eccentric is a more balanced type of construction than the crank throw type of crank shaft. These eccentrics are usually made of cast iron and are fastened to the steel crankshaft proper

by means of a locking screw. Basically, an eccentric consists of a cast iron disk placed off-center on the crankshaft. Many flywheels are given an unbalance and are so placed on the crankshaft that the flywheel unbalance neutralizes the unbalance of the crankshaft.

The parts are usually bolted together and sealed by means of either paper or lead gaskets. The special paper gaskets must be dehydrated (completely freed from moisture) before use in connection with most refrigerants and must be rubber free. The oil used varies with the refrigerants but dehydrated mineral oil is very good for practically all of them.

Where the crankshaft comes out of the crankcase to connect to the flywheel, a leak-proof joint or seal must be maintained. This seal must hold under all pressure conditions, and must withstand these pressures whether the crankshaft is stationary or revolving. The old style compressors used a combination of tallow and cord or asbestos and graphite packing compressed into a stuffing box between the crankshaft and the crankcase by a heavy spring. This packing needed frequent replenishing, however, and was soon discontinued in favor of the bellows (sylphon) seal. The bellows consists of a corrugated thin brass tube soldered to a ring of bronze and graphite at one end and to a flange at the other. The flange is fastened to the crankcase with a gasket between the two, while a spring presses the ring mounted on the other end of the bellows against a shoulder on the crankshaft. The two surfaces are perfectly smooth and under the 35-45 pound spring pressure, if lubricated with a little compressor oil, will stand most of the pressures ever encountered in a normal system. This seal is called the stationary bellows seal. Seals of this kind have been known to stay in service as long as 15 years and still give good service. Figure 17. Another seal construction attaches the gasket and bellows to the crank-

shaft. As the crankshaft revolves, the ring on the bellows will rub against a flat, smooth disk mounted on the crankcase. Figure 71.

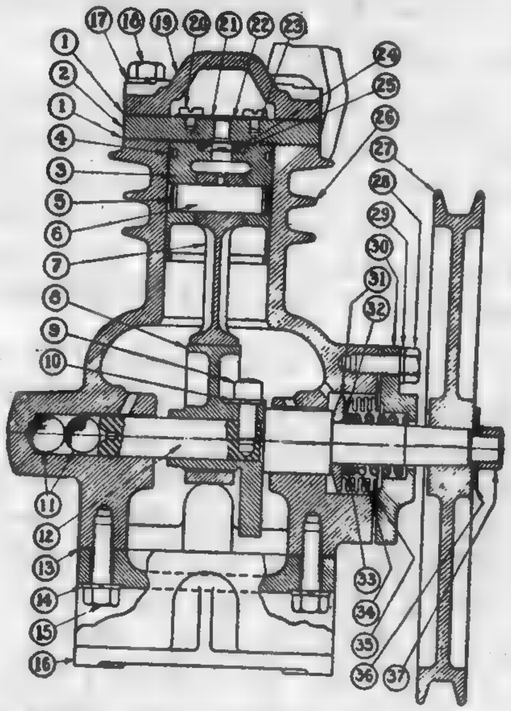


Fig. 17. A typical domestic one cylinder compressor
1. Cylinder head gasket; 2. Head valve plate; 3. Piston; 4. Piston ring; 5. Piston pin retainer; 6. Piston pin; 7. Connecting rod; 8. Eccentric; 9. Eccentric set screw; 10. Eccentric set screw lock washer; 11. Thrust ball bearings; 12. Crankshaft; 13. Base gasket; 14. Compressor base cap screw lock washer; 15. Compressor base cap screw; 16. Compressor base; 17. Head lock washer; 18. Head cap screw; 19. Compressor head; 20. Exhaust valve screw. 21. Upper exhaust valve; 22. Lower exhaust valve; 23. Exhaust valve spacer; 24. Intake valve retainer; 25. Intake valve; 26. Compressor body; 27. Flywheel; 28. Seal flange cap screw; 29. Seal flange cap screw lock washer; 30. Seal flange; 31. Sylphon seal; 32. Seal felt washer; 33. Seal spring washer; 34. Seal spring; 35. Seal flange gasket; 36. Flywheel washer; 37. Flywheel nut
(Courtesy of: Domestic Industries, Inc.)

The compressor valves are usually made of thin steel disks. These disks seat against cast iron shoulders constructed into the piston and the exhaust valve plate. Some constructions

use springs to keep the valve in place, while others use the pressure differences and the weight of the disk to do this. The flywheels are usually made of cast iron with a grooved periphery to fit a V-belt and are often fastened to the crankshaft by means of a taper, a Woodruff key, and a lock nut. Some flywheels are fabricated from stamped steel parts with the spokes formed into fan blades.

Because the temperatures in a refrigerating unit rarely exceed 140°F., very small clearances may be used between all the moving parts of the unit. Clearances of .0001 inch are very common. This clearance is so little that some manufacturers do not find it necessary to use piston rings on their pistons, as this clearance will not allow the pressures to force the gas past the piston. The purpose of the piston is to compress the gas admitted into the cylinder chamber into the high pressure side. The piston is designed to come as close as possible to the cylinder head without touching it in order to press practically all the gas into the high pressure side. This clearance between the piston and the cylinder head when the piston is at upper dead center is approximately .010 inch or .020 inch. The maximum lift allowed the valves without permitting them to become noisy is approximately .010 inch for both the intake and exhaust valves.

41. ROTARY COMPRESSOR:

Another very popular type of compressor is the rotary type which has some distinct advantages as far as vibration and moving parts are concerned. The materials of construction are very similar to those of the reciprocating pump, but its operation is very different. Its fundamental purpose is identical, for it takes the low temperature, low pressure gas, and converts it into a high temperature, high pressure gas, but the pumping effect is produced by a rotary motion rather

than a reciprocating motion. This pump is illustrated in Figure 18. There are two types of rotary compressors; some use sealing blades that rotate with the shaft (Figure 18), and a second type which is becoming very popular has the blade stationary, but the blade has a rubbing contact against the rotating shaft. Figure 56. The operation is as follows: The shaft rotates in a chamber so that the eccentric on the shaft or the enlargement of the shaft rubs constantly against the outer wall of this chamber. As the rotor turns around in this chamber, the blades imprison quantities of gas which are compressed into smaller spaces, building up their pressures and temperatures and finally releasing them into the high pressure side of the system.

In Figure 18 the low pressure gas (yellow) is imprisoned between two blades as the blades rub against the wall of the cylinder due to centrifugal force. When the rotor revolves (contra-clockwise in this case) the low pressure gas is gradually compressed into a high temperature, high pressure condition (blue). As the gas, now occupying very little space, comes opposite the opening (D), it passes into the high pressure dome because it cannot go through the point of contact between the rotor and the housing, labeled "X." The small clearance at this point (.0001 inch) plus the presence of lubricating oil makes the joint pressure tight. The gas cannot back up because of the rotating blade following it. Note that this compressor uses no eccentric, but that the rotor is mounted off-center enough to allow the rotor almost to rub against the housing at a point between the intake and exhaust ports. The brown portion in the illustration represents the oil reservoir on the high pressure side.

42. GEAR AND CENTRIFUGAL COMPRESSORS:

The gear type compressor is not used to any great extent at present. Figure 19. This compressor functions as follows:

With the gears driven as indicated by the arrows, the gas enters at the intake and is carried around in the spaces between the teeth until it gets opposite the outlet opening. Here it is forced to go out because the teeth meshing on the two gears displaces the gas. Rotary and gear compressors occasionally use check valves to prevent the high pressure gas from slowly flowing back into the cooling coil.

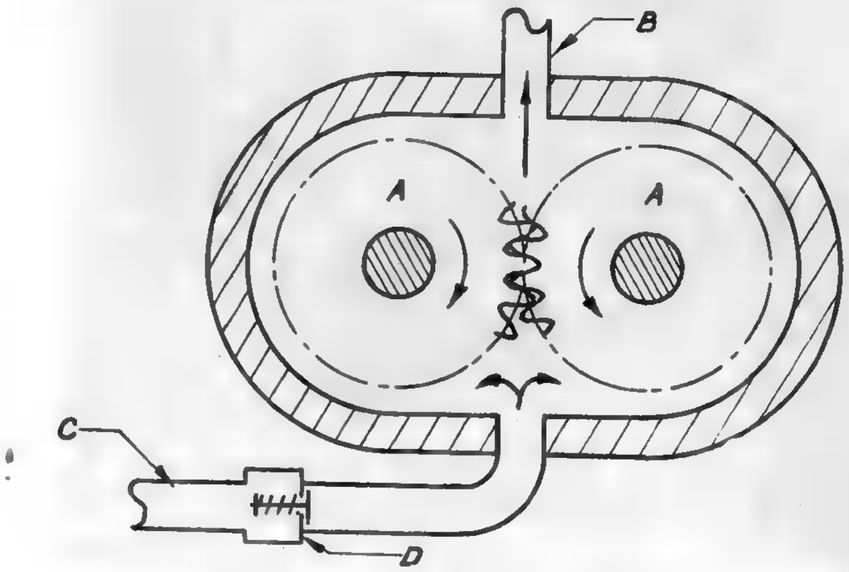


Fig. 19. A gear type compressor
A. Two herringbone gears; B. Compressed gas outlet; C. Low pressure gas inlet; D. A check valve

The centrifugal type compressor is used extensively in large air conditioning installations. This compressor operates on the principle of increasing the pressure by rapidly revolving circular impellers connected in multiple stages. Several of these impellers are mounted in series in one housing and are usually directly driven by a motor or steam turbine. Figure 19A. Refrigerants used with this type of compressor possess the ability to function with a low pressure difference between the high pressure and low pressure sides. Refrigerants such as

water, methyl formate, Freon F-11, etc., are frequently used in this type of installation.

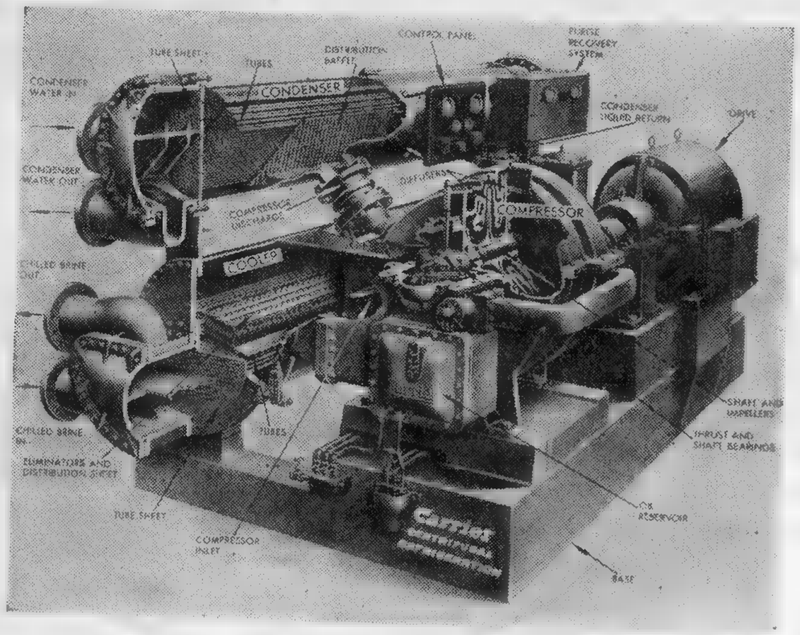


Fig. 19A. The centrifugal type compressor
(Courtesy of: Carrier Corporation)

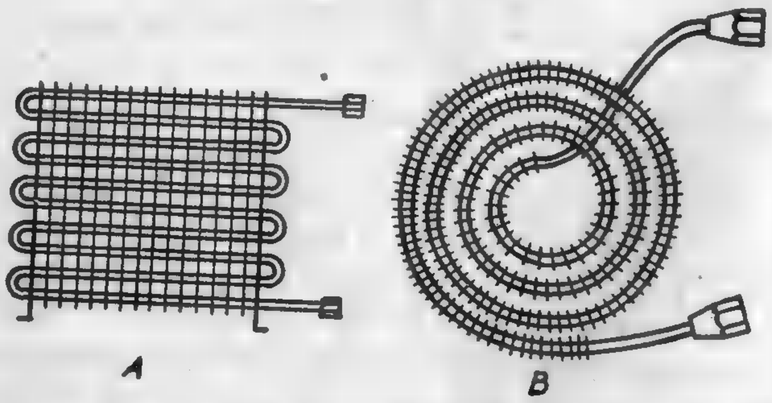


Fig. 20. Two typical air-cooled condensers
A. The flat coil type; B. The spiral type

43. THE CONDENSER AND RECEIVER:

The condenser is usually of copper tubing upon which fins have been fixed to assist the rapid radiation of heat or it may be water-cooled, but for domestic use it is usually air-cooled by forcing air over the fins by means of a fan attached to the electric motor. Figure 20.

Old models used plain tubing condensers, but this is now an obsolete practice. Copper fins attached to the tubes increase their surface and assist in cooling the condenser. Lint and

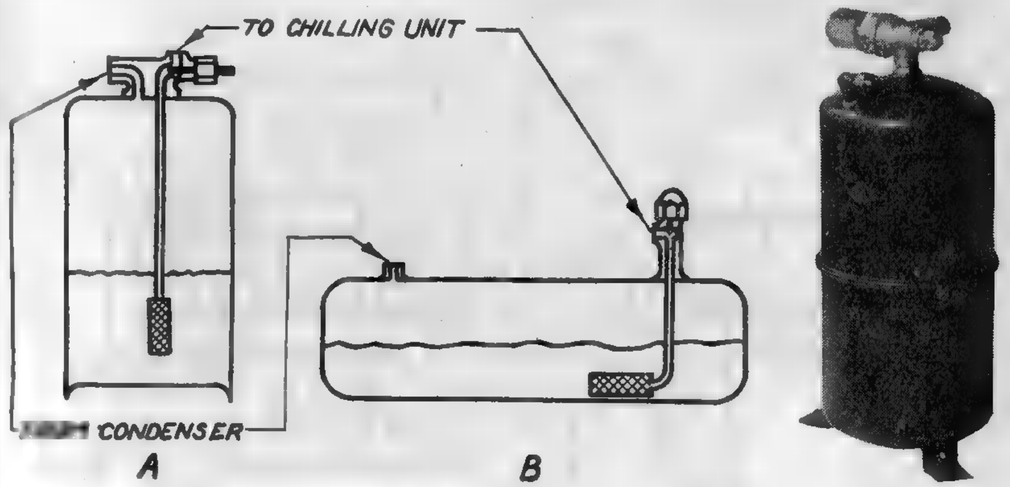


Fig. 21. Liquid receivers
A. The vertical type; B. The horizontal type
(Courtesy of: Norge Corporation)

dust must be removed from condensers regularly or it will interfere with proper cooling.

The liquid receiver is a storage tank installed for servicing purposes and also for taking care of variations in the amount of liquid refrigerant in the system. Figure 21. An excess of refrigerant is always stored in the liquid receiver, and when the mechanism is taken apart the service man usually stores all the refrigerant in the liquid receiver.

These liquid receivers are mostly commonly made of drawn steel shells welded together. Occasionally one will find a liquid receiver made of a cast material or built into the condenser, that is, the bottom tubes of the condenser form the liquid receiver. Practically all liquid receivers are furnished with a service valve by means of which the opening to the liquid line is controlled. A screen of fine copper mesh is usually found in the outlets of these liquid receivers in order to stop any

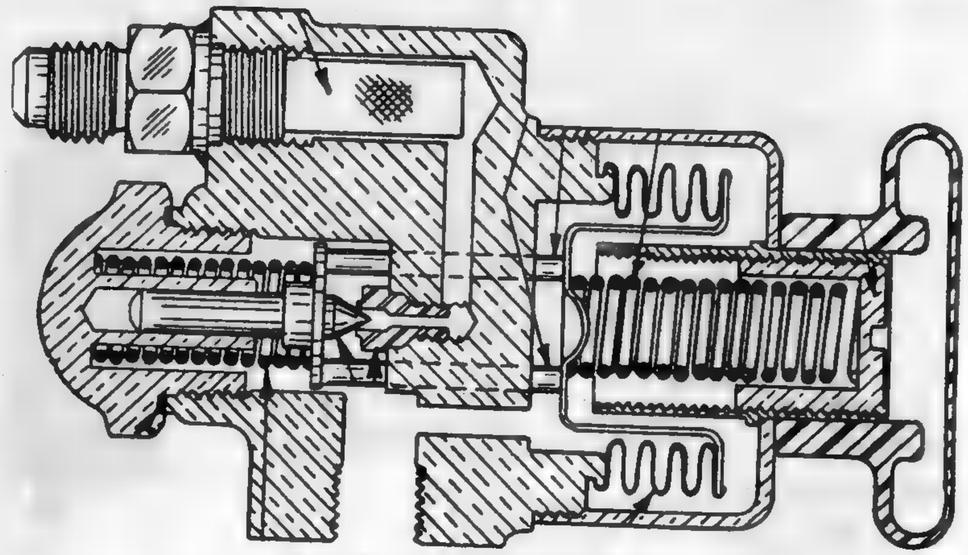
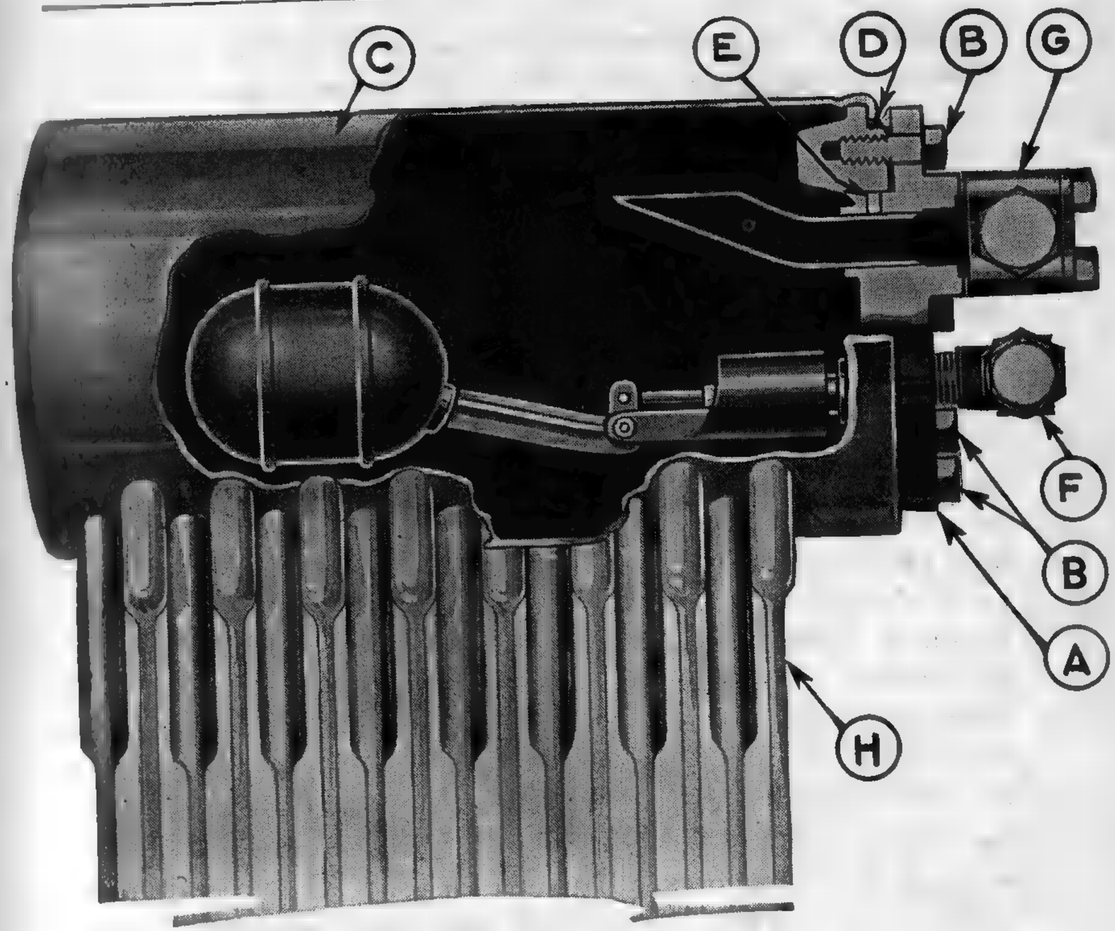


Fig. 22. An expansion valve
(Courtesy of: Kelvinator Sales Corporation)

particles of foreign substances from entering the refrigerant control valves.

44. EVAPORATOR OR COOLING UNIT:

The liquid is now led through the liquid line (high pressure) to the cooling unit where it is reduced to a low evaporating pressure by means of an expansion valve (dry system) or a float needle valve (flooded system). Figures 22 and 23. This low pressure results in a low boiling or evaporating tempera-



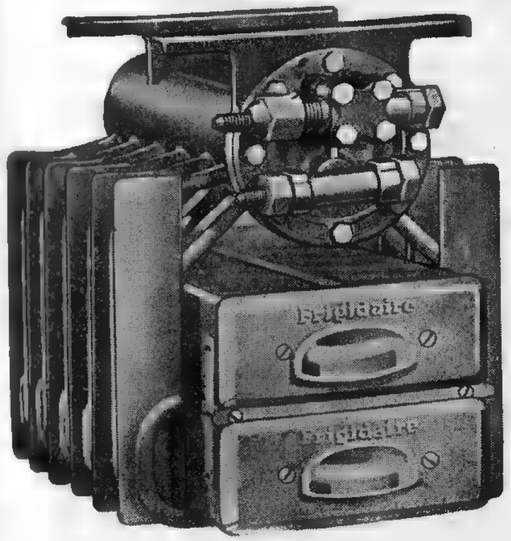


Fig. 23. A low side float cooling unit and valve
A. Header; B. Bolts; C. Float chamber; D. Welded joints; E. Lead gasket; F. Liquid line valve; G. Suction line valve; H. Refrigerant coils
(Courtesy of: Frigidaire Corporation)

ture for the refrigerant with the result that it evaporates and absorbs considerable heat. This absorption of heat is sometimes from the cooling unit brine which surrounds the coils, or the box may be cooled directly. The evaporated refrigerant now passes through the return or low pressure tube, which is larger than the liquid line or high pressure tube, back to the inlet on the compressor. All of the connections, mechanical, soldered, or brazed, must be very carefully executed to eliminate any possibility of a leak throughout the entire system.

Cooling units are made in three different styles depending upon the type of refrigerant control that is used in conjunction with them. If an expansion valve is used, the cooling unit consists of a coil of tubing sometimes submerged in a tank of brine to give it a longer hold-over period. This is shown in Figure 24. When a low side float control is used, the cooling unit consists of a tank out of which run very short lengths of tubing. The tank, of course, is to contain the float mechanism as illustrated in Figure 23. Note that the mechanism holding the float, called a header, is bolted to the cooling coil and also that shut-off valves are usually used on these float chambers. If it is a high side float or capillary refrigerant control, the cooling unit may be either a cast tank or a series of coils which will provide an evaporating surface for the refrigerant. The older styles used a fabricated sheet copper brine tank in which the cooling unit tray holders were constructed. The refrigerant flowed through copper coils submerged in the brine. The present tendency is to fabricate these units out of steel shells welded together and finished with porcelain on the outer surface. Lead gaskets are usually used wherever a joint needs to be sealed.

45. THE DRY OR DIRECT EXPANSION SYSTEM:

The dry system previously mentioned is that cycle where the refrigerant when passing from the liquid line to the evaporator is controlled by an expansion valve with a manual adjustment. That is, as the pressure lowers on the low side, the expansion valve opens and more refrigerant escapes into the evaporating coils where it absorbs heat upon evaporating on the low pressure side. This system operates independently of the amount of refrigerant in the system. Figure 24 shows a direct expansion system cooling unit. This dry system is

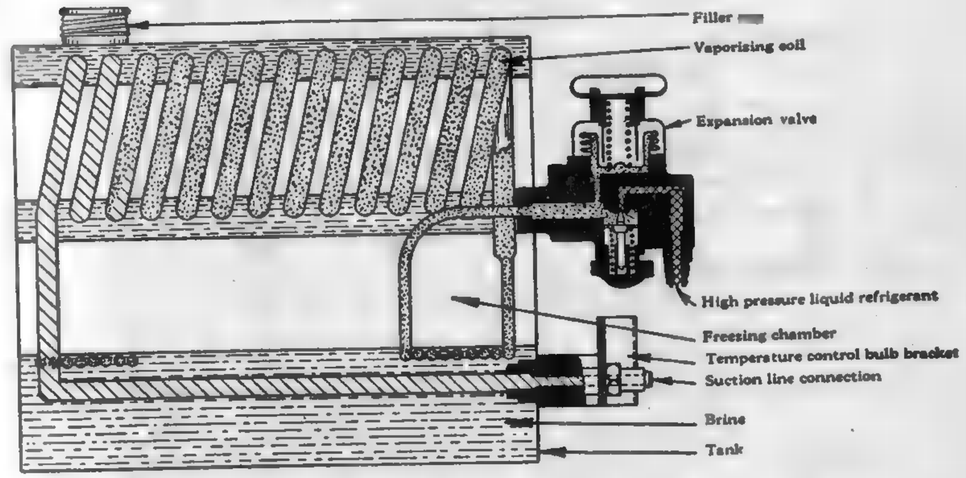


Fig. 24. A brine type dry cooling unit with an expansion valve
(Courtesy of: Kelvinator Sales Corporation)

slightly more expensive and is used in installations where a saving of space is an important factor.

The expansion valve is, therefore, one of the division points between the high and low pressure sides of the system. See Chapter VII for a detailed explanation of expansion valves.

46. CAPILLARY TUBE OR CHOKE TUBE:

Another method of throttling the high pressure liquid to a low evaporating pressure is to use a long length of small diam-

eter tube. This tube reduces the pressure due to the resistance to flow of refrigerant through the length of the small tubing. The tube is usually about 1/8 inch in diameter outside. It has a 1/16 inch inside diameter and is placed between the liquid line and the cooling coil. This inside diameter varies, depending upon the manufacturer. The Rice Company, which built a conventional refrigerator using the capillary tube, con-

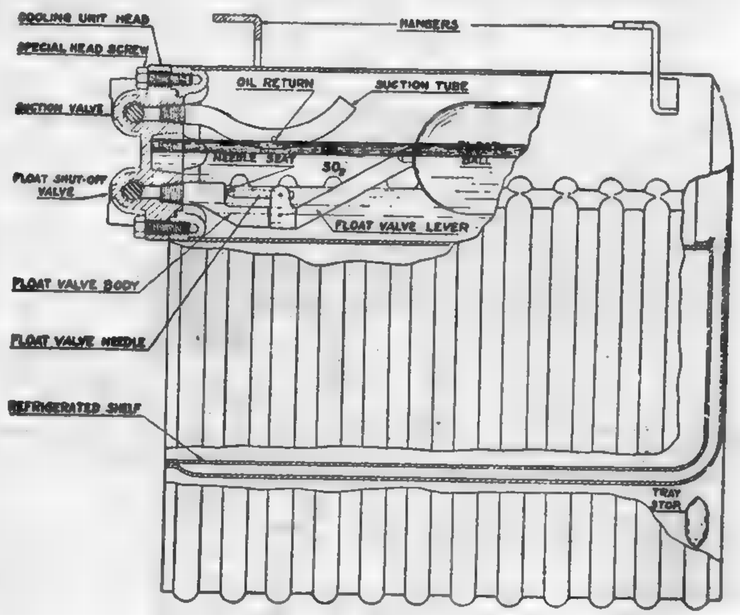


Fig. 25. A low pressure side float
(Courtesy of: Trupar Manufacturing Company)

structed these tubes into 3, 6, and 9 foot lengths. An illustration of the capillary tube may be found in Figure 38.

47. LOW PRESSURE SIDE FLOAT CONTROL (FLOODED):

Another type of refrigeration cycle using a compressor is the flooded system, which varies only from the dry system in

that the evaporating coil is flooded with refrigerant and the amount of the refrigerant is controlled by a float valve. It functions as follows: as heat is absorbed by the refrigerant in the cooling unit, it evaporates and consequently the liquid level falls, which naturally causes a lowering of the float. As the float lowers, it opens the needle valve connected to it, which allows more liquid to enter from the high pressure liquid line taking the place of the evaporated liquid. This makes a very simple unit with the one disadvantage of needing more

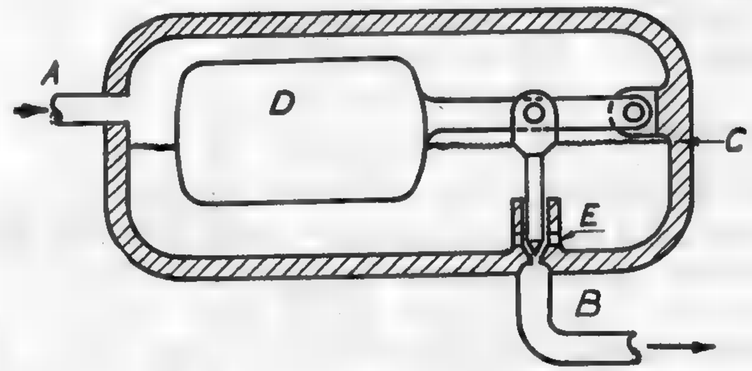


Fig. 26. A high pressure side float
A. Condensed liquid inlet; B. Liquid outlet; C. Liquid level; D. Float; E. Needle and orifice

refrigerant than the dry system. Figure 23 illustrates the exterior appearance of a flooded cooling unit, while Figure 25 explains the interior construction. The motor control is operated the same as in the direct expansion system type, but uses either a temperature or pressure control switch.

Take particular note of the lever mechanism and the oil layer over the refrigerant in Figure 25. The two floats illustrated are the ball type. In Figure 25 the construction is called the shell type, whereas, in Figure 23 the boiler and tubing construction is shown.

48. HIGH PRESSURE SIDE FLOAT CONTROL (FLOODED):

This system uses a float located in the liquid receiver tank or in an auxiliary chamber in the high pressure side. It operates as follows: When enough liquefied refrigerant has collected in the float chamber, the float will rise enough to open the needle valve and admit the liquid into the low pressure side or cooling unit. One can readily see that the amount of refrigerant in the system must be carefully regulated to allow it to operate correctly. Figure 26.

Paragraph 62 describes in detail a high side refrigerant control which is mounted on the condensing unit.

49. MOTORS:

The driving mechanism of these refrigerators is usually an electric motor. Small gasoline engines have been used for this purpose. Electric motors are of a very sturdy construction and their characteristics furnish high starting power. To insure quietness these motors are mounted on rubber or springs. The position of the motor is adjustable to facilitate belt adjustment. The size of these motors varies between $\frac{1}{20}$ H.P. and $\frac{1}{4}$ H.P. for domestic refrigeration with the $\frac{1}{5}$ H.P. and $\frac{1}{6}$ H.P. motors predominating. Chapter VIII explains the construction of these motors in greater detail.

50. MOTOR CONTROLS:

Practically all automatic electric refrigerators are designed to have an excess capacity and, therefore, under normal usage they need not run all the time. In the older styles of these refrigerators, the compressor would run approximately one hour and then be idle about two hours if the running temperatures were normal. Designers have gradually cut this cycling time down until at present, the mechanism runs approxi-

mately five to ten minutes and remains idle ten to twenty minutes. The total running time per day remains approximately the same; and under normal running temperature conditions it is eight to ten hours out of the twenty-four. There are two types of motor controls used to turn the motors on

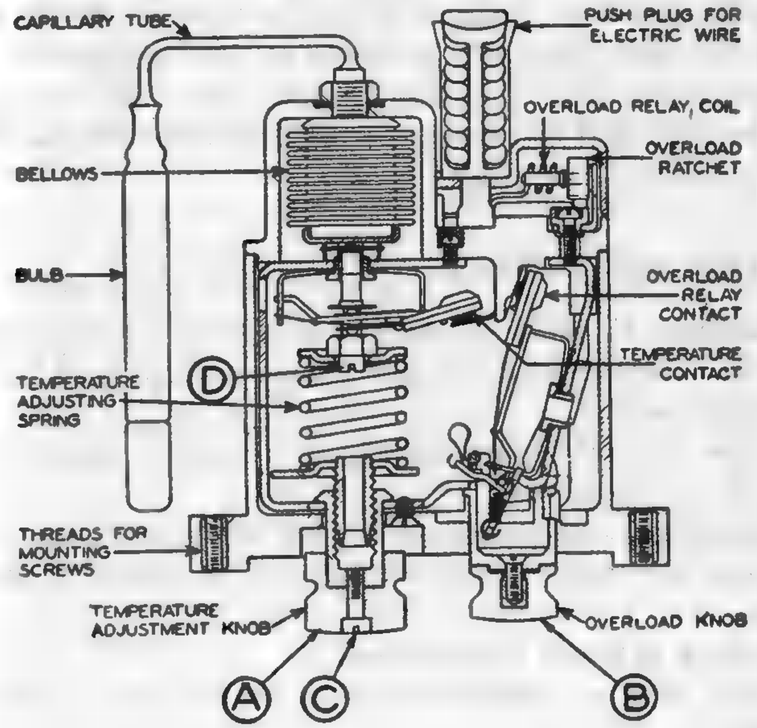


Fig. 27. A thermostatic motor control
A. Range adjusting knob; B. Overload knob and cut-out indicator; C. Screw for holding knob in place; D. Differential adjustment
(Courtesy of: The Sparks-Withington Company)

and off in order to obtain correct refrigeration. The pressure type of motor control is designed so that it shuts the electrical power off when the low side pressure of the system, corresponding to the temperature desired, indicates that the cabinet is cool enough. It turns the current on when the pres-

sure has risen to a predetermined pressure corresponding to the allowable temperature rise in the box. This pressure control is used only with the float systems or multiple systems. Another type of motor control is the thermostatic control which turns the motor off when the cooling unit gets sufficiently cool and turns it on again when the cooling coil has warmed up 8-10°. Figure 27. The student should keep in mind the fact that the pressure of the refrigerant in the system varies with the temperature; therefore temperature may be indicated by pressure. This permits the use of pressures to control temperatures.

51. REVIEW QUESTIONS:

The answers to these questions will be found on page 805.

1. How many laws of refrigeration are considered in refrigeration work?
2. Name the eight important parts found in all compression cycle refrigerators.
3. Name the parts commonly located in the low pressure side.
4. Name the parts commonly located in the high pressure side.
5. Name 4 types of compressors.
6. What kind of condensing units do not use a crankshaft seal?
7. In Figure 16 name the numbered parts 1 to 5.
8. Why are check valves used in the suction line on some rotary compressors?
9. Why should condensers be cleaned occasionally?
10. What name is applied to the type of cooling coil that uses an expansion valve?
11. What control determines the refrigerator cabinet temperature?
12. Name three types of refrigerant controls.

13. What advantage does an eccentric crankshaft have over a crank throw type?
14. How much clearance is allowed between the piston and the cylinder?
15. What is the volume of the compression chamber when the piston is at upper dead center?
16. How much lift is allowed the intake and exhaust valves?
17. The low side float maintains a constant ——— on the low side.
18. The expansion valve maintains a constant ——— on the low side.
19. The high side float maintains a constant ———.
20. What is the purpose of the crankshaft seal?
21. Another word for "evaporation" of a liquid is ———.
22. In Figure 24 the cooling unit tubing is enclosed in a ———.

CHAPTER III

THE ABSORPTION SYSTEM

The absorption system differs from the compression system in that it uses heat energy instead of mechanical energy to make a change in the conditions necessary to complete a refrigerating cycle. This system uses gas, kerosene, or an electric heating element as a source of heat supply.

There are two principal types of absorption refrigerators, one utilizing a solid absorbent material, the other using a liquid absorbent.

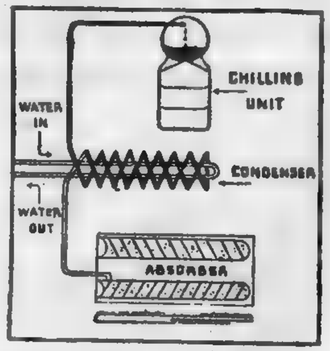


Fig. 28. Elementary solid absorbent cycle
(Courtesy of: Faraday Refrigerator Corporation)

These two types of absorption refrigerators are typified by the Faraday, which is a solid absorbent type and by the Electrolux, which uses a liquid absorbent.

52. THE ABSORPTION SYSTEM:

Figure 28 illustrates a simple absorption system. This diagram is of the solid absorbent type and is produced for the purpose of comparison with mechanical types of refrigerators.

The condensing coil, receiver, and cooling coils are quite similar to those used in the compression system. The compressor, however, has been replaced by a heater or generator. The system does not work so simply as the illustration portrays, but functioning of it may be more easily followed by leaving out the various controls that are explained in detail later.

The most appealing feature of this system is the elimination

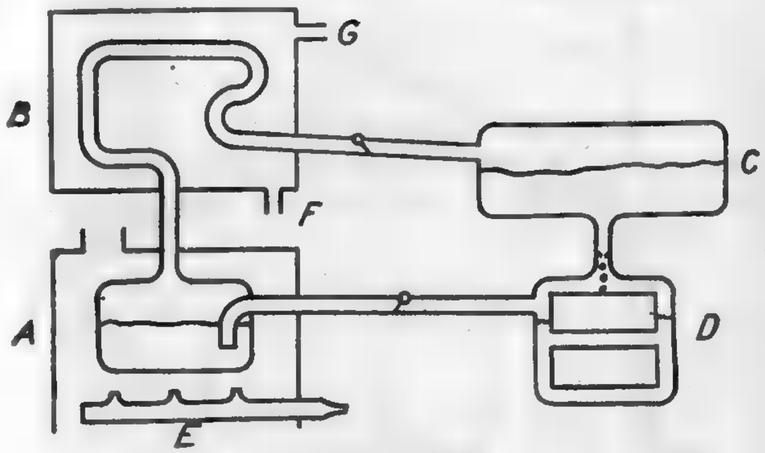


Fig. 29. Elementary liquid absorbent cycle
A. Generator; B. Condenser; C. Receiver; D. Cooling coil; E. Burner; F. Water-in; G. Water-out.

of moving parts down to a few valves, while certain domestic applications have moving parts reduced to a minimum.

Figure 29 illustrates a simple absorption system of the liquid absorbent type.

53. THE SOLID ABSORBENT SYSTEM (FARADAY):

Michael Faraday, in 1824, performed a series of experiments to liquefy certain "fixed" gases — gases which certain scien-

tists believed could exist only in vapor form. Among them was ammonia, for it had always been regarded as a "fixed" gas. Faraday knew that silver chloride, a white powder, had the peculiar property of absorbing large quantities of am-

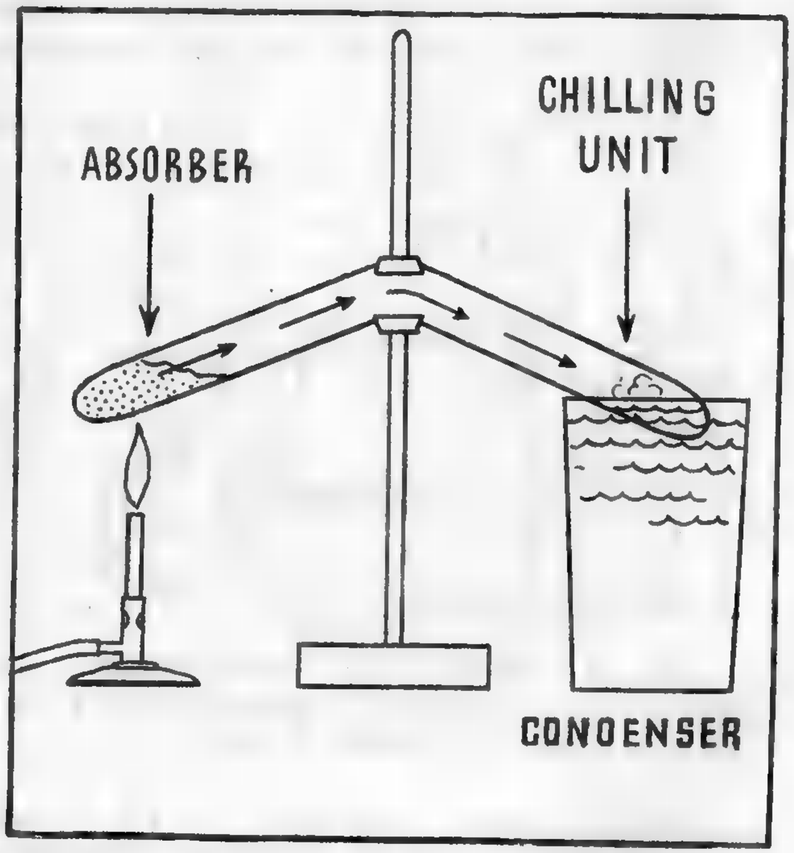


Fig. 30. Elementary operation of the intermittent absorption cycle
(Courtesy of: Faraday Refrigerator Corporation)

monia gas. He therefore exposed silver chloride to dry ammonia gas. When the powder had absorbed all of the gas it would take, he sealed the ammonia-silver chloride compound in a test tube which was bent to form an inverted "V." He then heated the end of the tube containing the powder and at

the same time cooled the opposite end of the tube with water. The heat released ammonia vapor and drops of colorless liquid soon began to appear in the cool end of the tube. Thus liquid ammonia was produced for the first time.

Faraday continued the heating process until sufficient liquid ammonia had been produced for his purpose. When this was accomplished he extinguished the flame under the powder and proceeded to observe the characteristics of the newly discovered substance.

A few moments after the flame had been extinguished, Faraday began to note a most unusual occurrence. The liquid ammonia, instead of remaining quietly in the sealed test tube, began to bubble and then to boil violently. It was rapidly changing back into a vapor, and the vapor was being reabsorbed by the powder. Upon touching the end of the tube containing the boiling liquid, Faraday was astonished to find it intensely cold. Ammonia, in changing from liquid to vapor form, extracted heat and it took this heat from the nearest thing at hand, which was the test tube itself.

The diagram in Figure 30 illustrates the Faraday experiment.

54. A TYPICAL SOLID ABSORBENT SYSTEM:

From Figure 28 the following elementary cycle may be traced. Heat is applied to the generator or absorber, which will liberate ammonia gas from its absorbent and drive it in a gaseous state up to the condenser where the vapor is liquefied by cooling.

The liquid refrigerant is forced from the condenser to the receiver or storage tank by the pressure of the vapor entering the condenser.

After sufficient ammonia is driven into the condenser and receiver, the heat is discontinued and the generator or absorb-

er cools. When the temperature of the absorber is lowered sufficiently, it begins taking back or reabsorbing the ammonia gas.

The apparatus is so constructed that it can obtain this ammonia only from the cooling unit, which necessitates an evaporation taking place there. From elementary physics one knows that this will cause the removal of heat from the cooling unit and its surroundings, and if this cooling unit is located in an insulated box (a refrigerator box) that box will be refrigerated.

As the ammonia evaporates from the cooling unit it is replaced by liquid ammonia from the receiver. This operation continues until the proper amount of ammonia is reabsorbed by the generator, when heat is again applied and a new charge of ammonia is stored in the receiver.

From the description it is seen that the cycle is intermittent and that the complete cycle embraces both a generating period and an absorbing period. This cycle may be easily traced from Figure 85.

This in principle is the Faraday refrigerator and its cycle is explained in detail in Chapter VI.

55. A TYPICAL LIQUID ABSORBENT SYSTEM (ELECTROLUX):

The liquid absorbent system seems to possess some very desirable characteristics. Water at ordinary pressures and temperatures will absorb great quantities of ammonia. Ammonia absorbed in water may be easily driven from the water by the addition of heat. Also liquid ammonia has a high latent heat of vaporization. Figure 11.

The water-cooled Electrolux is a very ingenious domestic refrigerator which is designed to operate in a continuous cycle and has no moving parts or valves other than for the control

of the burner flame and of the temperature of the circulated cooling water. The refrigerant is ammonia with water used

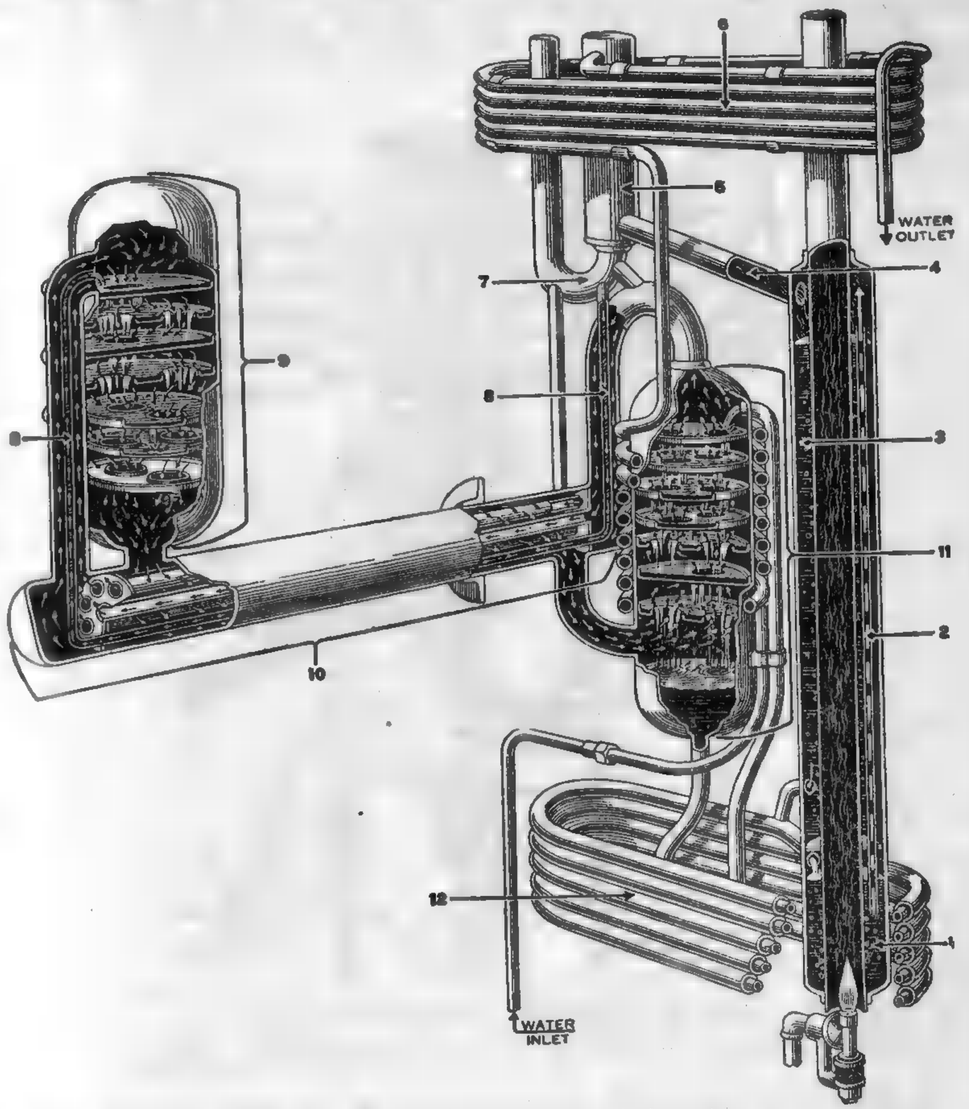


Fig. 81. Electrolux water-cooled system
(Courtesy of: Electrolux Refrigerator Sales, Inc.)

as the absorbent; hydrogen gas is utilized to create a partial pressure to allow the ammonia to evaporate at a low pressure.

When the burner is lighted and its heat applied at the base of the generator No. 1, Figure 31 and 32, ammonia vapor is released from the solution. This hot vapor passes upward through the percolator tube No. 2, and as the hot ammonia

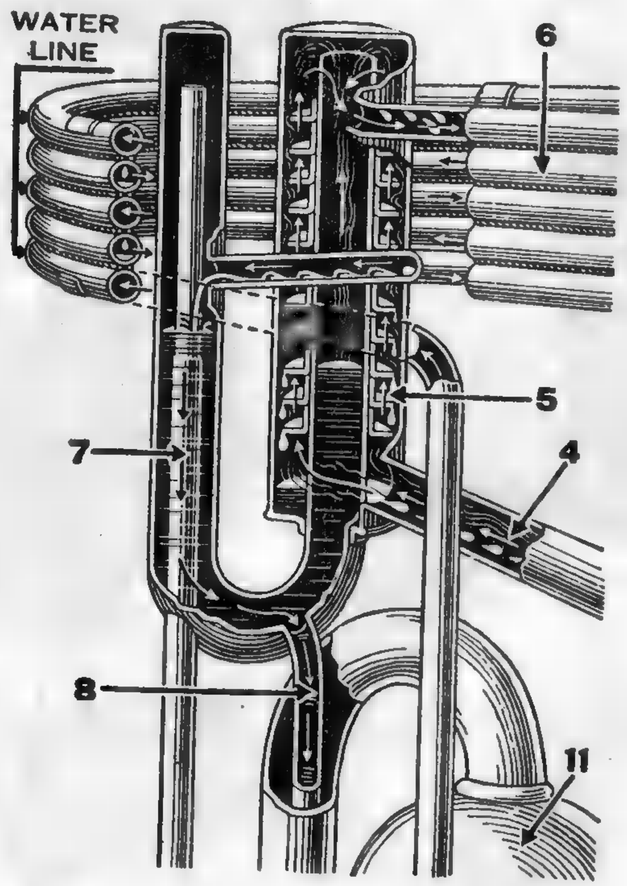


Fig. 32. Electrolux water-cooled system
(Courtesy of: Electrolux Refrigerator Sales, Inc.)

vapor rises through this tube it not only carries heat and a small quantity of water vapor, but actually forces the weak solution to the upper level of the generator.

Most of the water vapor in the strong solution condenses

here, and with the weak solution spills over the top of the percolator tube dropping back into the generator and down to the lower level No. 3. The hot ammonia vapor, being light, continues to rise into the analyzer tube No. 4. As the hot ammonia vapor passes upward through the analyzer tube, more water vapor is removed while the hot ammonia vapor goes on into the rectifier No. 5.

The rectifier consists of a series of small steel baffle plates, surrounding one leg of a U-tube; because the hot ammonia vapor still has some traces of water vapor, which must be removed in order to have pure ammonia vapor, the hot ammonia vapor is made to pass over these baffle plates, where the last of the water vapor condenses and flows back through the analyzer tube No. 4 to the generator No. 3.

The heat from the gas flame has at this point completed its work. For the remainder of the cycle, the natural force of gravity is depended upon to create circulation.

The pure hot ammonia vapor now continues into the condenser No. 6. This condenser consists of two parts: A layer of steel tubing through which the hot ammonia vapor passes, and a layer of copper tubing through which cooling water flows. These two tubes are soldered together to obtain a solid contact for interchange of heat.

The cool water, passing through the copper tube, takes out the heat from the ammonia vapor, thus condensing the vapor. The ammonia is now in a pure liquid state, and flows back into the U-tube No. 7.

The U-tube is the receiving and storage compartment in the cycle where the liquid ammonia is allowed to build up to a predetermined level; then it flows into the liquid ammonia tube which passes through the heat exchanger No. 2. The ammonia is here cooled before it reaches the cooling unit.

Because a liquid will always seek its own level, and since the U-tube is at a higher level than the cooling unit, the liquid

ammonia flows by gravity through the liquid ammonia tube and spills into the cooling unit No. 9.

As the liquid ammonia falls into the cooling unit, it forms in large shallow pools on a series of horizontal baffle plates. The hydrogen that is being fed to the cooling unit permits the liquid ammonia to evaporate (Dalton's principle). During this process of evaporation, the ammonia absorbs heat from the food compartment of the refrigerator and causes the water in the ice-cube containers to freeze. The ammonia vapor formed by the evaporating of the liquid ammonia, mixes with the hydrogen. This mixture is heavier than hydrogen alone and therefore settles downward through the bottom of the evaporator into the gas heat exchanger No. 10. This circulation is continuous in the cooling unit. The mixed gases then pass through the gas heat exchanger and are heated, which conserves energy by preheating the gases before they pass into the absorber No. 11.

During this time a weak solution of ammonia and water is being carried from the generator No. 3 to the top of the absorber No. 11 where it falls upon the baffle plates. Here it meets the mixture of hydrogen and ammonia vapor coming from the evaporator by way of the gas heat exchanger. The weak solution absorbs the ammonia vapor. The hydrogen is left free; since hydrogen is insoluble in water and is very light, it now rises to the top of the absorber and returns to the cooling unit.

The absorber is surrounded by the condensing water coil to cool the weak liquid. The cooling of the weak solution helps it to absorb the ammonia gas out of the mixture of ammonia and hydrogen. Also when the weak water solution absorbs the ammonia gas, considerable heat is liberated and the water-cooling coil must remove this heat to permit the refrigeration to continue.

The solution, now a *strong* solution of ammonia and water, drops to the bottom of the absorber and continues down through the liquid heat exchanger No. 12.

The liquid heat exchanger carries the strong liquid, or refrigerant, back to the generator No. 1 where it again starts its cycle.

The apparatus is a welded assembly. Figure 33. There are no moving parts to wear out and go out of adjustment. The total pressure throughout the cycle is about 200 pounds per square inch, necessitating a rugged construction which always insures a long life. This refrigerator is considered to be unique among the domestic ones sold in the United States. A more detailed study is made of the Electrolux in Chapter VI. In 1934 the Electrolux Company produced an air-cooled absorption refrigerator and discontinued the water-cooled one. See Chapter VI for complete details of this new model.

56. KEROSENE BURNING REFRIGERATORS (INTERMITTENT):

A very convenient refrigerator cycle for localities not furnished with gas or electricity is the Superfex and Trukold cycle. The Superfex cycle is basically the Faraday principle but incorporates features which warrant a description.

Ammonia is mixed with water in a tank or generator (A) under which are located some kerosene burners (M). The burners are lighted and the heat produced drives the ammonia in vapor form out of the mixture. This ammonia vapor is forced up a pipe (D) and through a coil (E) which is immersed in water contained in a tank (B) on top of the refrigerator (note arrows Figure 34). The lower temperature causes the ammonia vapor to change back to a liquid. This liquid ammonia drops through a pipe into the liquid receiver (C) and from here it passes to the cooling unit (K)

which is surrounded by a brine (H). One should note that the liquic receiver is insulated (F) which is to prevent this container from overcooling the food compartment by acting as the cooling coil. This process continues for a relatively short time until the kerosene is consumed and the burners go out. The ammonia will evaporate at a very low temperature in the cooling unit because as the generator cools it tends to re-absorb the ammonia. This evaporation causes the cooling effect on the contents of the food compartment which is called refrigeration.

In detail, the water in the generator (A) cools very quickly after the burners have gone out, and as cool water has a strong affinity for ammonia, the ammonia vaporized in the cooling unit passes back (note arrows Figure 35) to the generator through a connecting pipe (G) and is re-absorbed by the water in the generator maintaining a low evaporating pressure in the cooling unit.

In other words, the heat from the oil burners drives the ammonia from the generator (A) to the cooling unit (K) *in a short time;* the ammonia in the cooling unit vaporizes and passes back to the generator *slowly* over a period of twenty-four to thirty-six hours. The vaporization of the ammonia in the cooling unit produces the refrigerating effect.

For additional efficiency in unusually hot climates or for handling extra large loads, a depression (L) in the top of the condenser tank may be filled with water which will evaporate rapidly and aid the cooling of the tank.

This refrigerator is also explained in Chapter VI along with the Trukold and Icy-ball which are fundamentally similar to it.

All of the refrigerators based on the Faraday principle are rapidly becoming very popular as household refrigerators. Without exception the absorption mechanisms are provided with a fuse plug which will release the charge from the mech

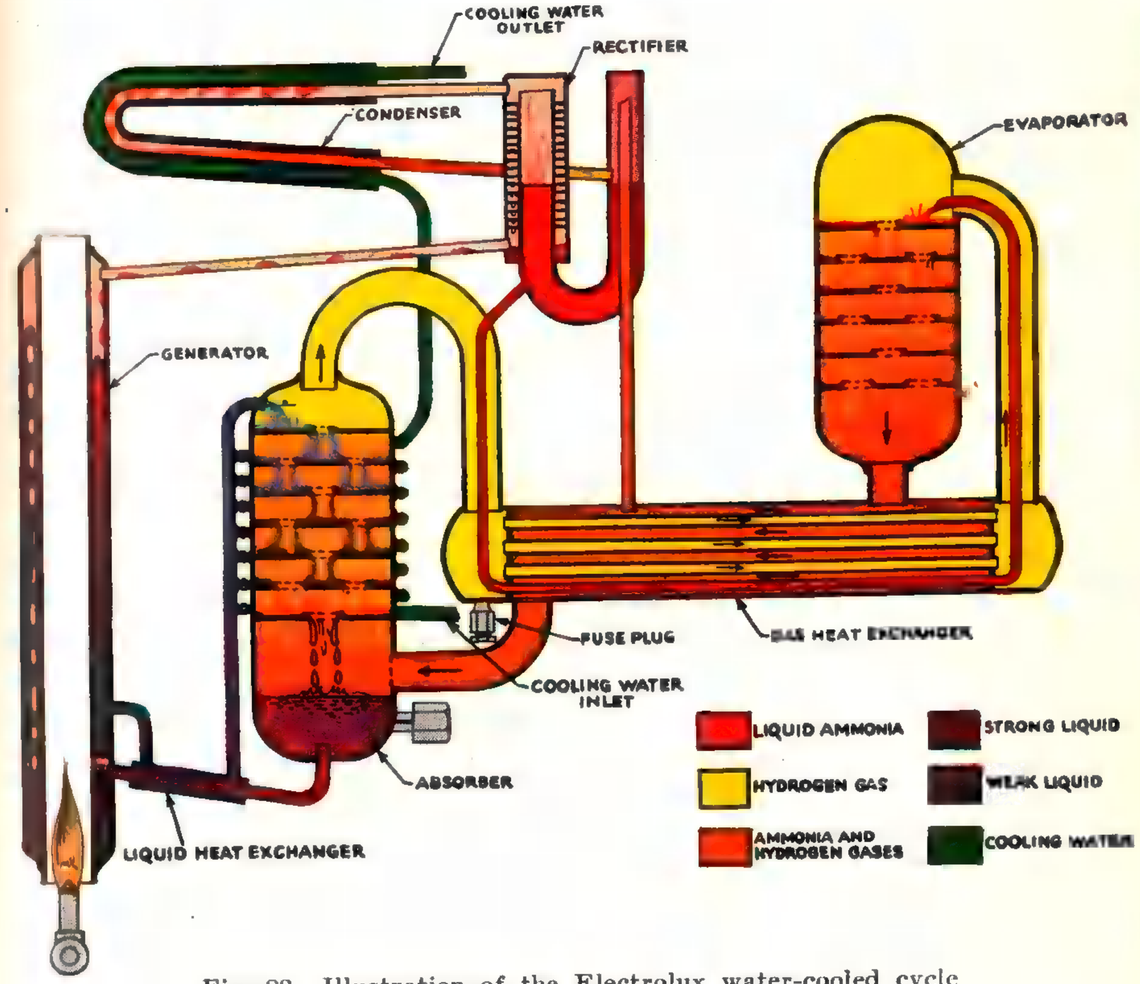


Fig. 33. Illustration of the Electrolux water-cooled cycle
(Courtesy of: Electrolux Refrigerator Sales, Incorporated)

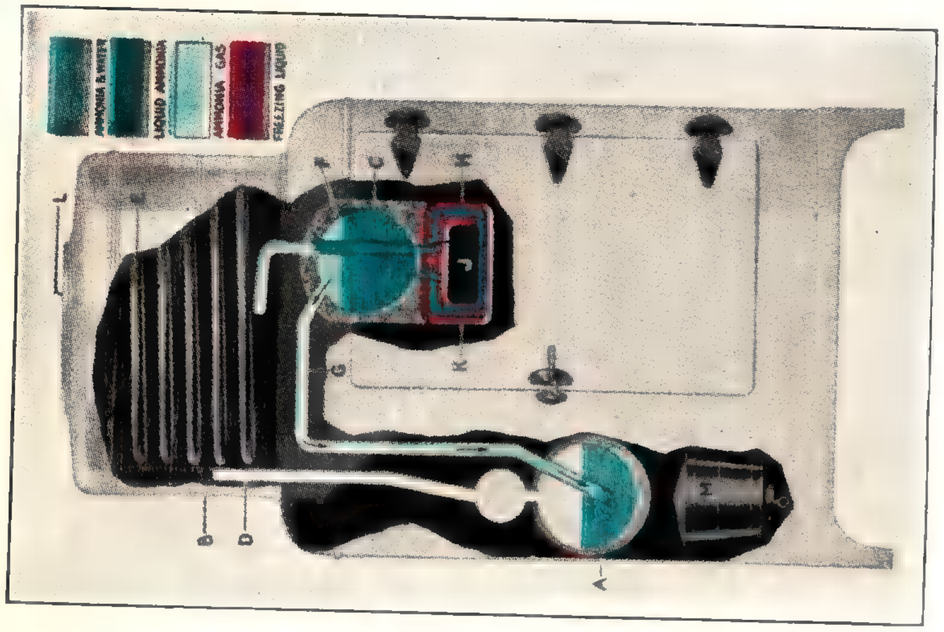


Fig. 35. The cooling period in an intermittent type absorption refrigerator
(Courtesy of: Perfection Stove Company, Incorporated)

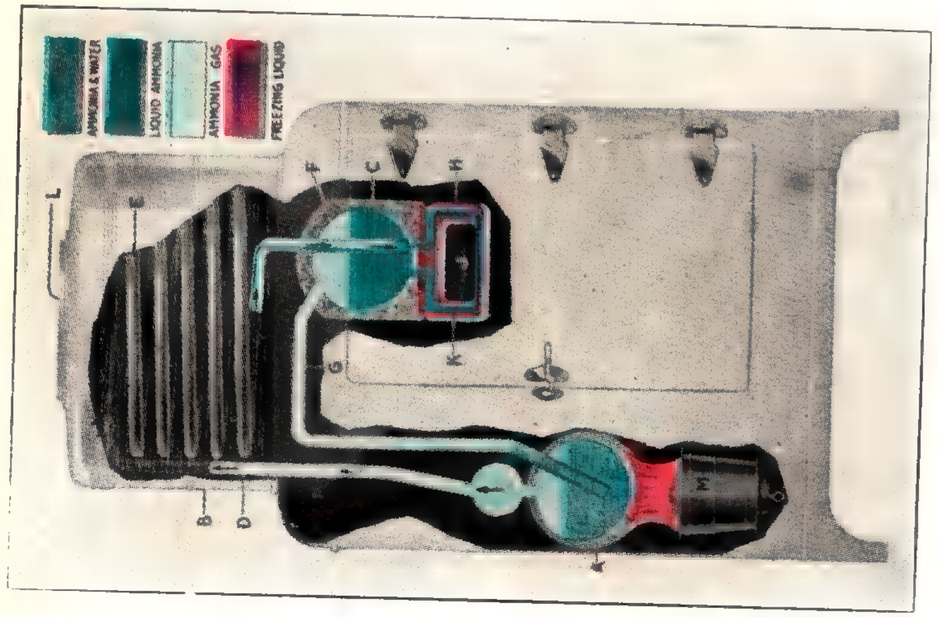


Fig. 34. The generation or heating interval in a typical intermittent type absorption refrigerator
(Courtesy of: Perfection Stove Company, Incorporated)

anism when the temperature of the unit becomes excessive 175-200°F. This device prevents any possibility of the complete mechanism ever exploding.

An absorption refrigerator using sulphur dioxide as the refrigerant was produced a few years ago but did not continue on the market. It was of the intermittent type using silica-gel as the absorbent material. The action was very similar to action in the intermittent types just explained. This absorption system is used on some railroad freight cars.

57. REVIEW QUESTIONS:

The answers to the following questions may be found on page 806.

1. Name the lettered parts of Figure 29.
2. Why is the ammonia and water combination so popular?
3. What purpose does the hydrogen serve in the Electrolux?
4. What localities are especially in need of the kerosene-fired intermittent absorption refrigerators?
5. Who first discovered the absorption principle?
6. Why must the absorber be cooled in the Electrolux cycle?
7. What is the purpose of a heat exchanger?
8. How can burning more gas in the Electrolux cycle produce more cold?
9. Why is the storage cylinder or receiver in the Superfex refrigerator insulated?
10. Why are these mechanisms provided with a fuse plug?
11. Name three substances used in absorption refrigerators to absorb the refrigerant gas.
12. In absorption refrigerators, does the liquefication of the refrigerant depend upon compression?
13. Referring to Figure 33, identify the substance represented by each color.

14. Does the generator serve any other purpose in the Superfex? What?
15. Have absorption refrigerators using sulphur dioxide ever been used?

CHAPTER IV

CONVENTIONAL DOMESTIC COMPRESSION CYCLE REFRIGERATORS

Because of using the same fundamental cycle, a great number of the refrigerators on the market are very similar in so far as their operation, control, servicing, and use are concerned. All the refrigerators mentioned in this chapter use a vertical reciprocating compressor of the one and two-cylinder design and are air-cooled. They differ quite radically occasionally in the design of their valves and other minor features that are of interest only to the service man. They are all equipped with three or more service valves located in the same relative position. However, in order to insure an understanding of the cycle and of the features of construction of these refrigerators, certain ones are explained in detail.

The selection of refrigerators for this study has been made from those for which instructional material was not readily available and from those of conventional design. Necessary servicing information for most popular refrigerators will be found in Chapter XI. Refer to Chapter XIX for detailed specifications of all refrigerators.

58. COPELAND:

The Copeland refrigerator, manufactured by the Copeland Products Company formerly of Mt. Clemens, Michigan, but now of Sidney, Ohio, is made in numerous designs involving both commercial and domestic refrigeration equipment. The Copeland Company was organized in the early twenties. A typical Copeland domestic design may be followed in Figure 36. This refrigerator uses iso-butane (Freezol) as the refrigerant, which is a special refrigerant that has been used only

by the Copeland people in their domestic refrigerators. Their first refrigerators used glycerine as a lubricant for the compressor, and they were equipped with a glycerine trap located at the outlet of the discharge service valve. Having confined all of their designs to iso-butane and methyl chloride refrigerants, their systems have naturally used the expansion valve type of refrigerant control except in the oldest commercial models which used a low side float. Until 1933 this company used methyl chloride in their commercial installations and iso-butane in their domestic installations. Beginning with 1933 and continuing to date they have used methyl chloride in all of their units. In 1932 the company produced a directly driven reciprocating compressor of the package type in which the motor was enclosed with the compressor eliminating the crank shaft seal. This unit was designed to mount in the top of the box in such a way that the cooling unit was suspended below the condensing unit and separated from it by an insulated wall. In the illustration (Figure 36), the discharge service valve is labeled as valve B, the suction service valve is labeled A, and the liquid receiver service valve is labeled C by this company. Notice the screen location in the liquid receiver. The discharge service valve is placed below to permit installation in a smaller space. The oil plug on the side of the crankcase is typical and determines the oil level. Note that the suction line connects to the crankcase of the compressor and the intake valve is in the head of the piston. This is a popular arrangement. There are three reasons for connecting the suction line to the crank case either directly or indirectly in order that the crank case pressure will be the same as the suction pressure. These reasons are: (1) it returns the oil to the crankcase as some oil always circulates with the refrigerant; (2) it simplifies the construction; (3) it maintains a controlled crankcase pressure. The brine tank cooling unit consists of a tinned copper tank fitted with sleeves

for the ice-cube trays and refrigerant tubing connected within the tank.

The expansion valve illustrated in Figure 36 is one of the original Detroit Lubricator automatic expansion valves; it is fastened to the cooling coil by means of a two-bolt flange and a lead gasket. The liquid line is ¼ inch tubing and runs from the valve labeled C, which is fastened to the condensing unit frame, along the back of the cabinet to the expansion valve. The suction line and the liquid line are run together as much as possible to give a heat-exchanging effect. This increases the efficiency of the machine. The tubes are fastened to the various parts of the unit by means of the standard S.A.E. flared connection. The cooling coil is called a four-tray coil although the actual number of trays is three. The double tray, being of double depth, is considered as two trays. These trays slide into sleeves soldered into the brine tank. Within the brine tank are located the tubes carrying the refrigerant. This tubing is coiled as close as possible to the ice-cube sleeves.

The service valves are labeled A, B, and C. Valve A is the suction service valve. It is a two-way valve permitting the installation of a compound gauge into the system for checking low side pressure. Valve B is the discharge service valve; it also is a two-way valve permitting the installation of a high pressure gauge into the system for checking the high side pressures. Each of these two valves are fastened to the compressor by two 5/16 inch S.A.E. bolts; a paper gasket seals the flange. Valve C is commonly called a liquid receiver service valve, and is a one-way valve used to stop the flow of liquid refrigerant from the liquid receiver into the liquid line.

The fan shown back of the condenser is mounted on the electric motor shaft together with a grooved pulley. The motor is connected to the compressor by means of a V-belt. Note that the base of the compressor is removable to permit

one to remove and repair the piston and connecting rod assembly.

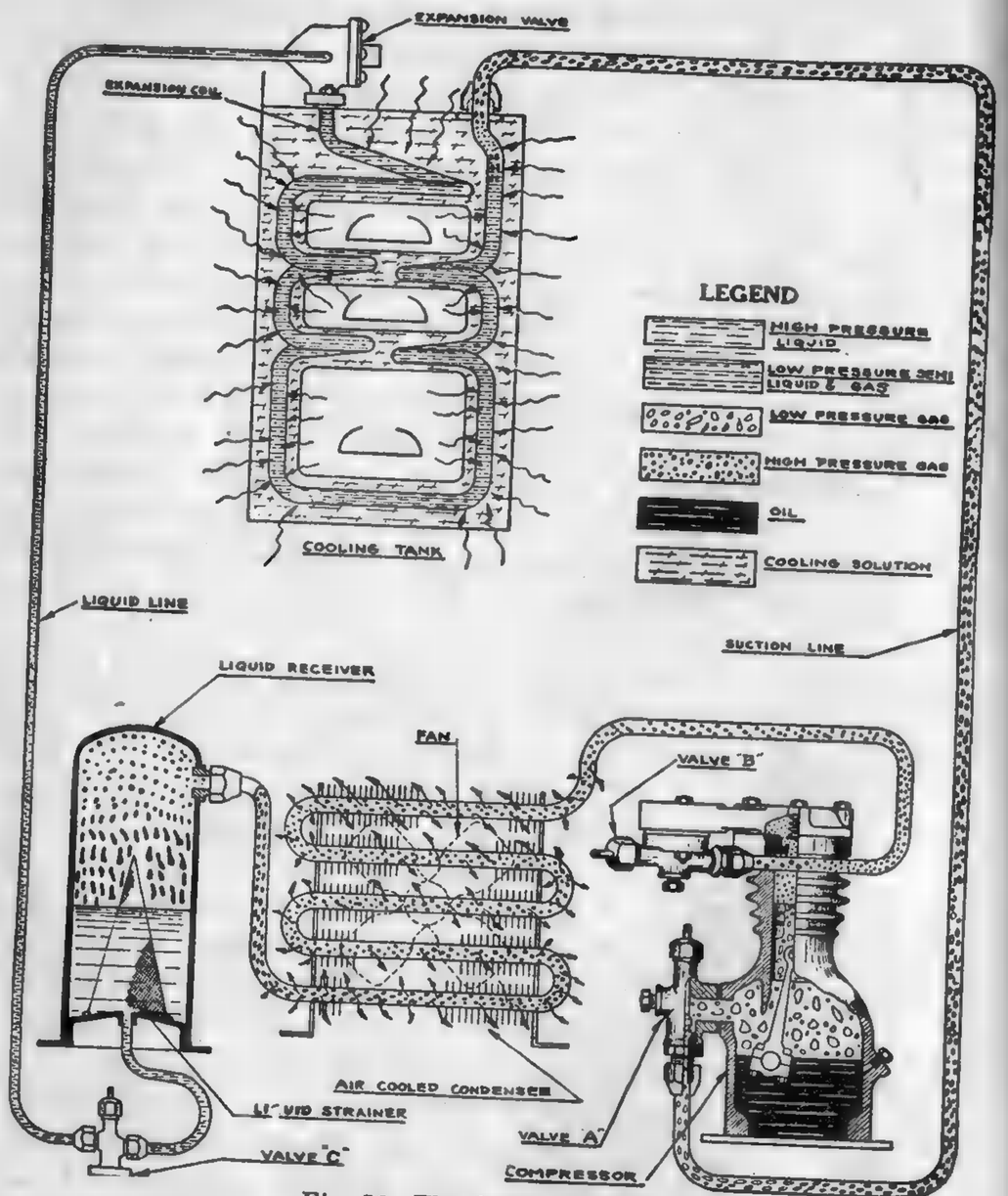


Fig. 36. The Copeland cycle
(Courtesy of: Copeland Sales Company)

The compressor shown in Figure 37 is very efficient and durable. The illustration is self-explanatory, but one should give special attention to the taper shaft and Woodruff key method of attaching the flywheel, also the method of attaching the piston pin to the piston. Note the characteristic curved spokes on the flywheel. Specially treated paper gaskets are used throughout the compressor.

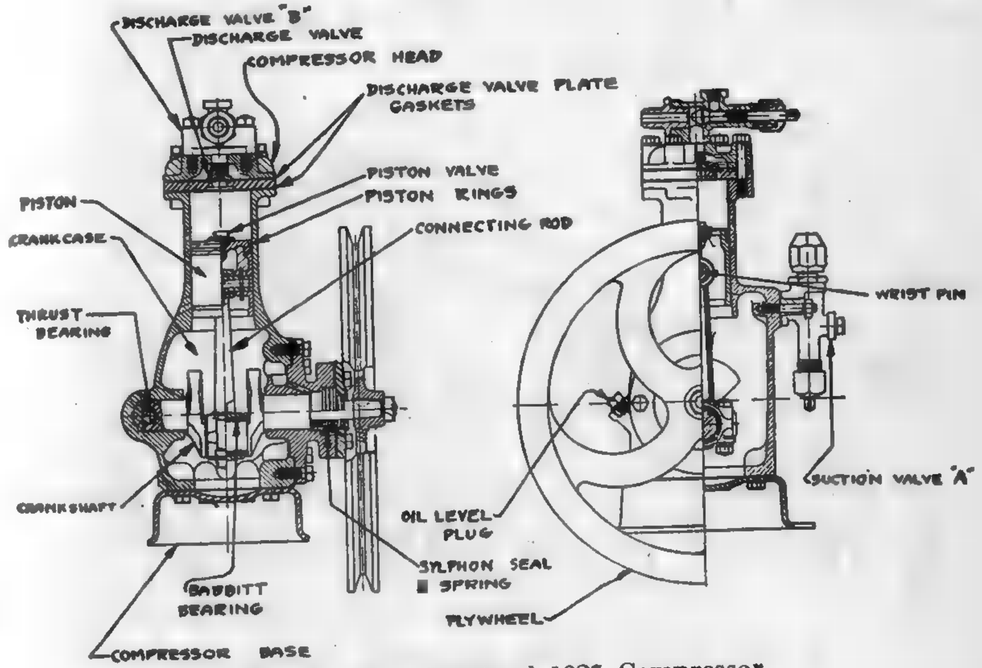


Fig. 37. The Copeland 1927 Compressor
(Courtesy of: Copeland Sales Company)

59. CROSLEY:

The Crosley Radio Corporation of Cincinnati, Ohio, has been producing a package type of refrigerating unit for several years. The Crosley cabinets are well known because of their Shelvador design. The company's condensing and cooling units are so designed that they may be removed in one piece from the cabinet. The cycle and operation of this company's

1932 model may be easily followed in Figure 38. The unit uses sulphur dioxide as the refrigerant and the refrigerant control is of the capillary tube type construction. This capillary tube is mounted between the filter and the cooling unit. Note that it does not have a liquid receiver. A liquid receiver is not necessary due to the capillary tube refrigerant control. Also, the quantity of refrigerant put in the system is carefully measured. The lower tubes of the condenser serve to store

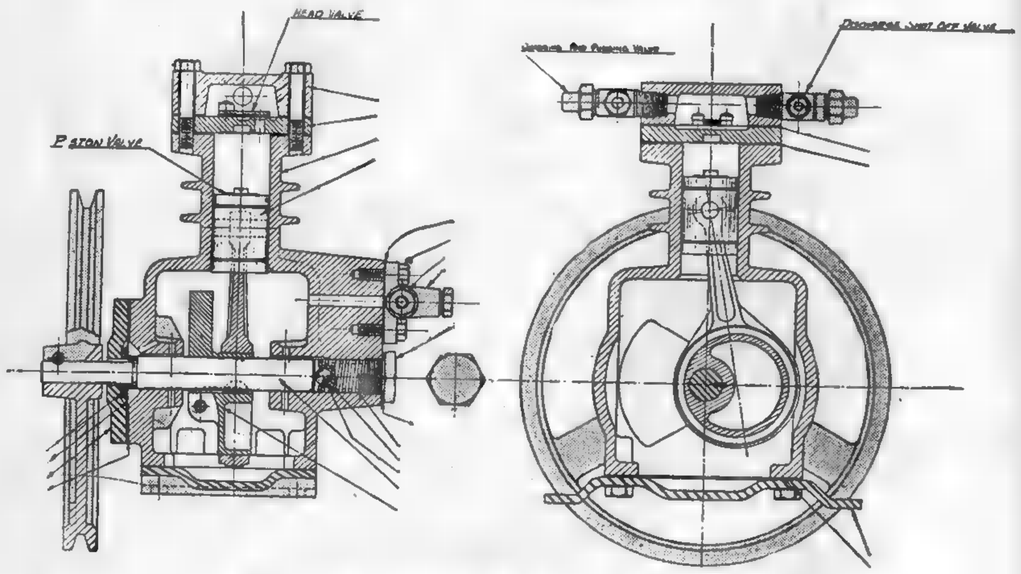


Fig. 39. The compressor used in the Crosley unit
(Courtesy of: The Crosley Radio Corporation)

sufficient quantities of liquid refrigerant. The compressor design shown in Figure 39 has the following features: instead of a two-way discharge service valve, this compressor uses two one-way service valves. One is located between the condenser line and the cylinder head, and the other is used as a charging valve or for connecting the high side gauge into the system.

The intake valve, a spring steel disk, is located in the piston. An eccentric is used instead of the usual crankshaft.

and it is fastened to the compressor shaft by a bolt and key in addition to the typical Woodruff key design. Lubrication is by oil splash, and wells are used to feed the oil to the bearings and seal. The crankshaft seal is of the diaphragm type backed by a rubber washer with the seal pressure exerted by a spring at the opposite end of the crankshaft. The complete condensing unit is mounted on springs to minimize vibration. The cylinder has integrally cast air-cooled fins to reduce the temperature of the compressor.

60. FRIGIDAIRE:

The Frigidaire Corporation, Dayton, Ohio, a subsidiary of General Motors Corporation, was one of the first companies to enter the small-unit refrigeration field. This company started building refrigerators about 1920 and have continued to extend their line until now they are producing domestic, commercial, ice-cream, and air-conditioning systems. Frigidaire used sulphur dioxide exclusively until recent years when they started using a refrigerant called Freon, sometimes known as F-12, in some of their units.

Their first refrigerator used a two cylinder gear-driven sulphur dioxide compressor with a water-cooled condenser and liquid receiver combination. The water-cooling coil was located inside a dome which in turn was bolted over the two cylinders. For this reason it was called the dome type of compressor. This model used a high side float, located in the dome. Later models used a low side float valve, built into a brine tank type of cooling unit. Figure 40. The crankshaft seals of these compressors were of the graphite and asbestos packing style and were backed up by large coil springs to compensate for wear. This construction is called a stuffing box seal. The gear on the motor was made of fiber and was of helical design. A 1/4 H.P. or 1/3 H.P. repulsion-induction

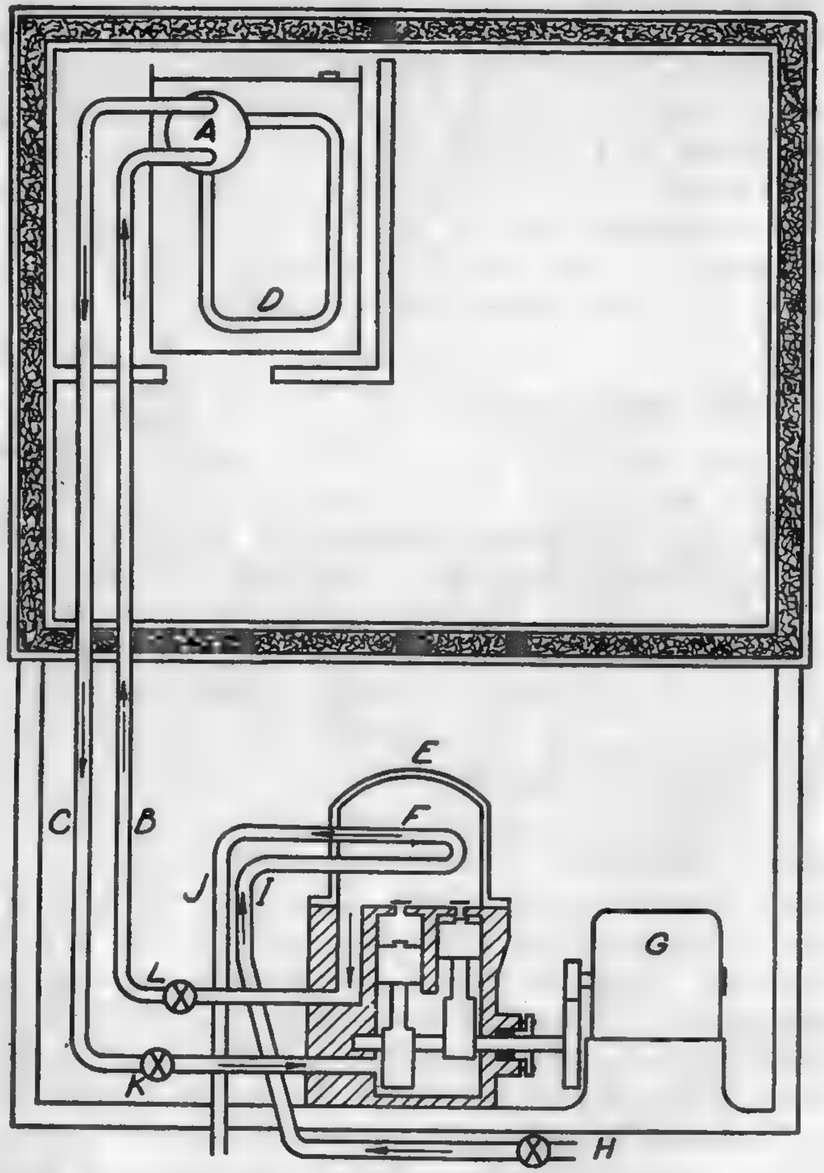


Fig. 40. The Frigidaire dome type refrigerator
A. Cooling unit; B. Liquid line; C. Suction line; D. Brine tank; E. Dome; F. Water coil; G. Motor; H. Water valve; I. Water-in line; J. Water-out line; K. Suction line valve; L. Liquid line valve

type motor was used. The first of these models were equipped with very few service valves, but the later ones have service valves located on both the compressor and cooling unit. The motor control first used was of the thermostatic type. The control element was mounted in the cooling coil. The motor switch was connected to this control element by a ¼ inch copper tube. In cases of remote installation, it was necessary to run the third tube from the condensing unit to the cooling unit and then charge it. Later machines used the pressure type motor control, which was adjusted with sliding weights. This control also had a sliding weight high side pressure safety cut-out which would shut off the motor in case the water supply was stopped and the condensing pressure ran too high. The water control valve was also incorporated in this apparatus, being operated by the high pressure bellows lever.

In Figure 41 one should notice the method of fastening the cast-iron eccentric to the hardened steel crankshaft. The connecting rod is of cast-iron and is self-aligning on the eccentric. This compressor has the intake valve located in the piston, and the piston uses two piston rings. Note the steel disks and the spring arrangement for taking care of the end thrust on the crankshaft in Figure 42. This company has produced many different styles of refrigerating units. A typical Frigidaire product is a package type of unit, the compressor design of which may be followed in Figures 41 and 42. In this model an expansion valve refrigerant control is used and the compressor has two suction service valves and two discharge service valves. The unit illustrated in Figure 43 was produced in the late twenties and used (as shown) a low side float valve, a pressure motor control, a flywheel fan to cool the condenser, and a complete set of five servicing valves. Note that all the service valves are capped to protect the valve stems. The cooling coil hangar straps are of typical

construction. Most of the Frigidaire compressors have the cylinder bolted to the crankcase and the crankcase has a solid bottom cast integral with it. The motor control has an easily

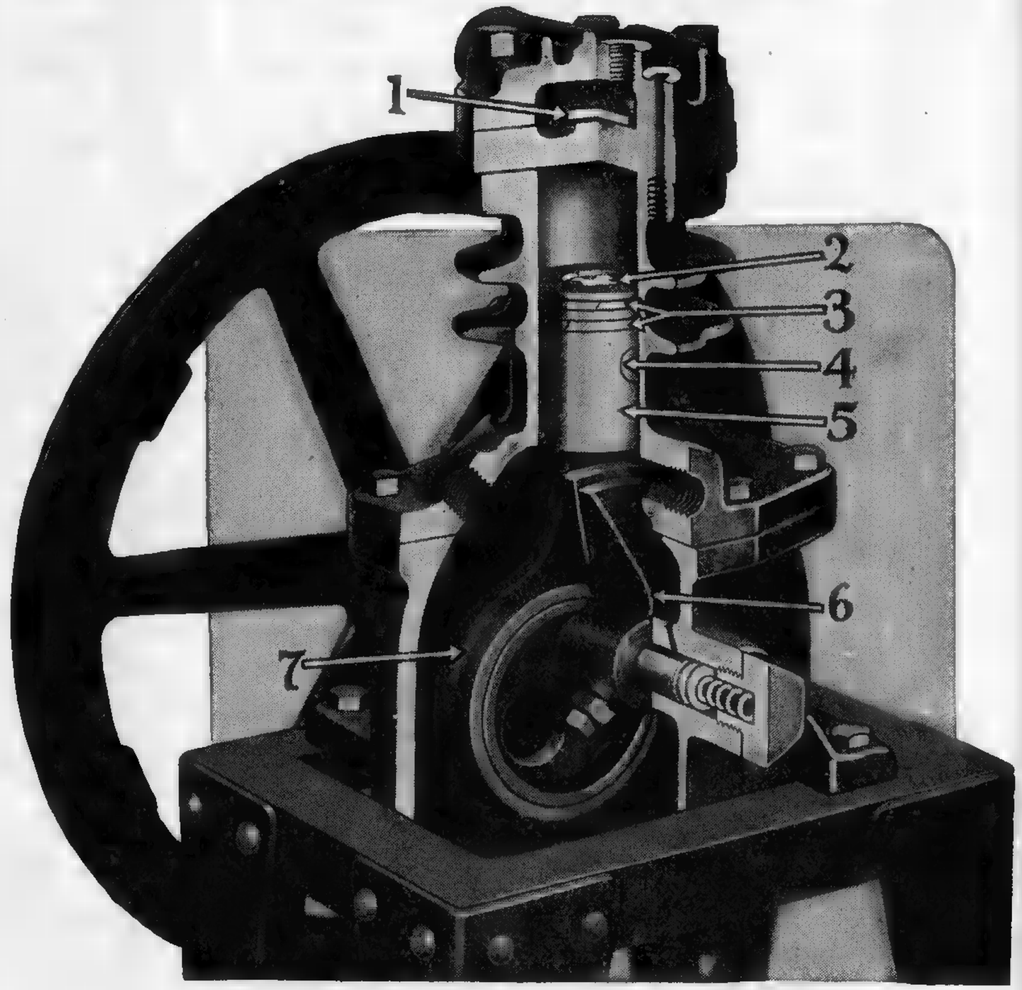


Fig. 41. A Frigidaire compressor
A. 1. Exhaust valve; 2. Intake valve; 3. Piston rings; 4. Piston pin; 5. Piston; 6. Counter weight; 7. Connecting rod

manipulated cold adjustment and a motor overload cut-out located in a small metal box below it.

In 1934 the company produced two different machine units which have been continued with certain refinements in 1935. Their Super line uses a twin cylinder compressor with both

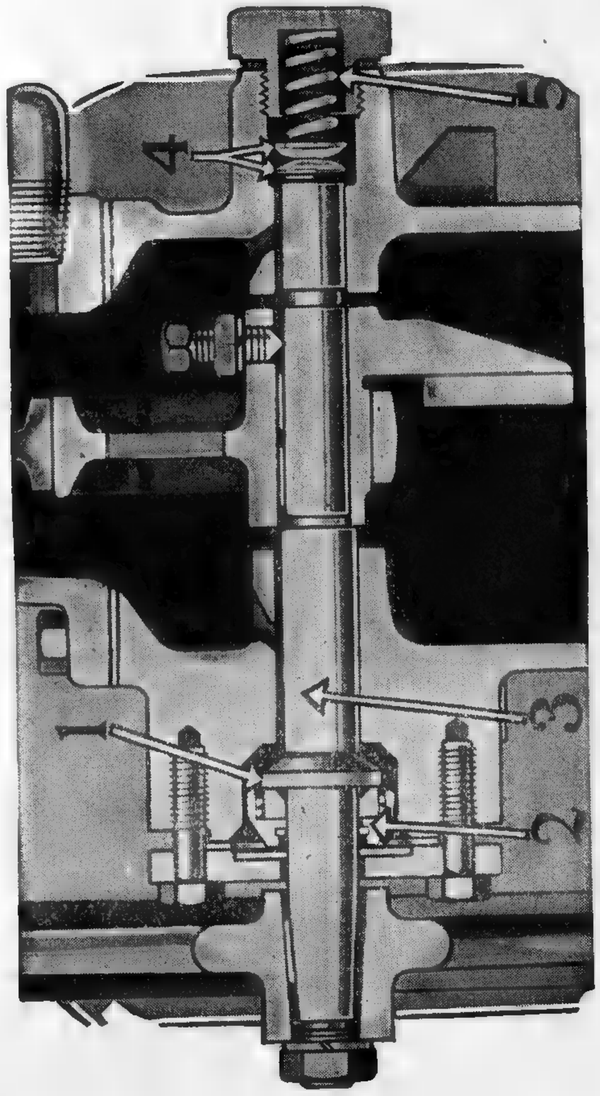


Fig. 42. A Frigidaire compressor cut-a-way, showing seal
1. Crankshaft seal shoulder; 2. Seal ring; 3. Crankshaft; 4. End thrust discs; 5. End thrust spring.
(Courtesy of: Frigidaire Corporation)

the suction service valve and the discharge service valve built into the compressor head. Figure 44. A high side float refrig-

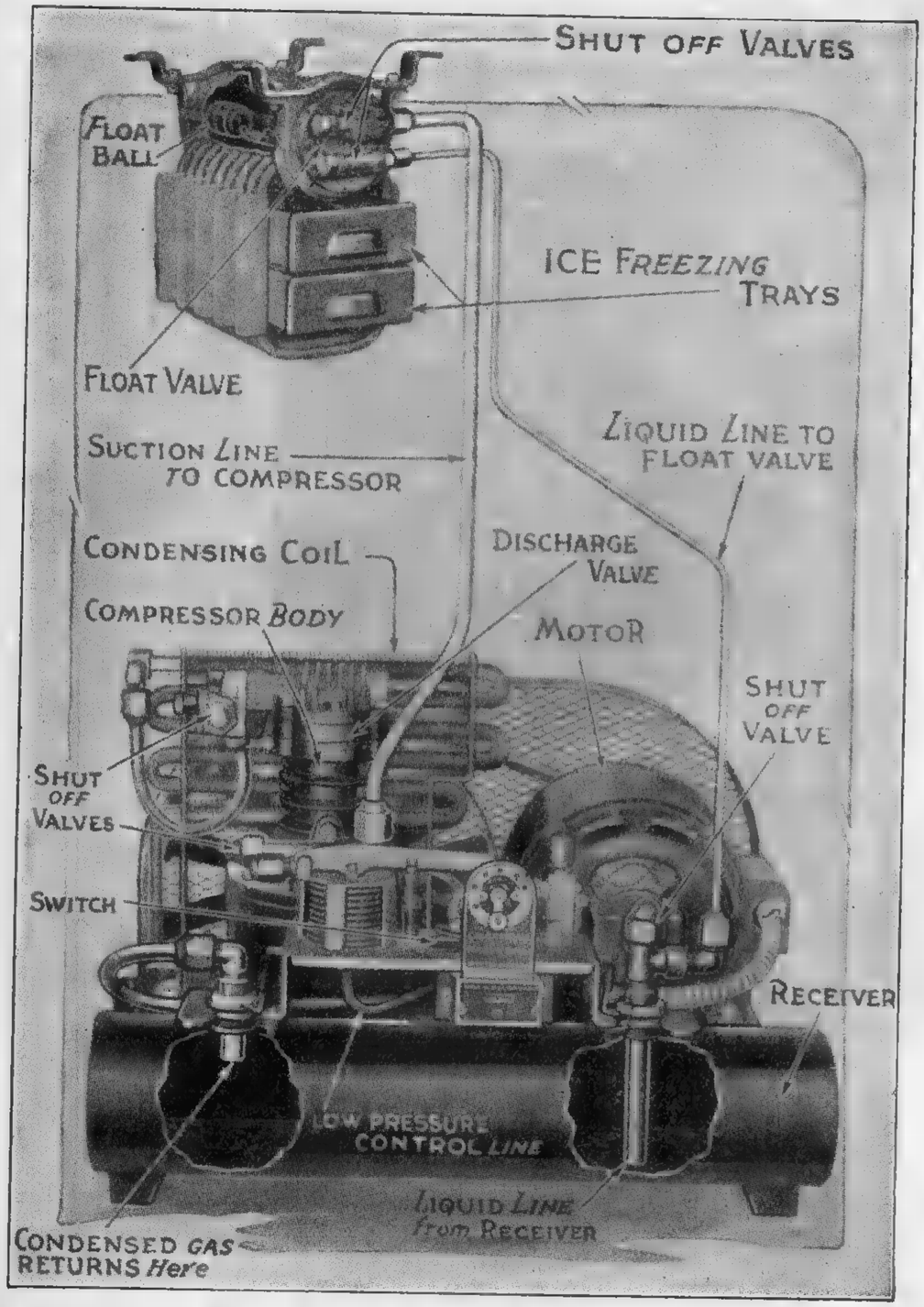


Fig. 43. A Frigidaire low side float unit
(Courtesy of: Frigidaire Corporation)

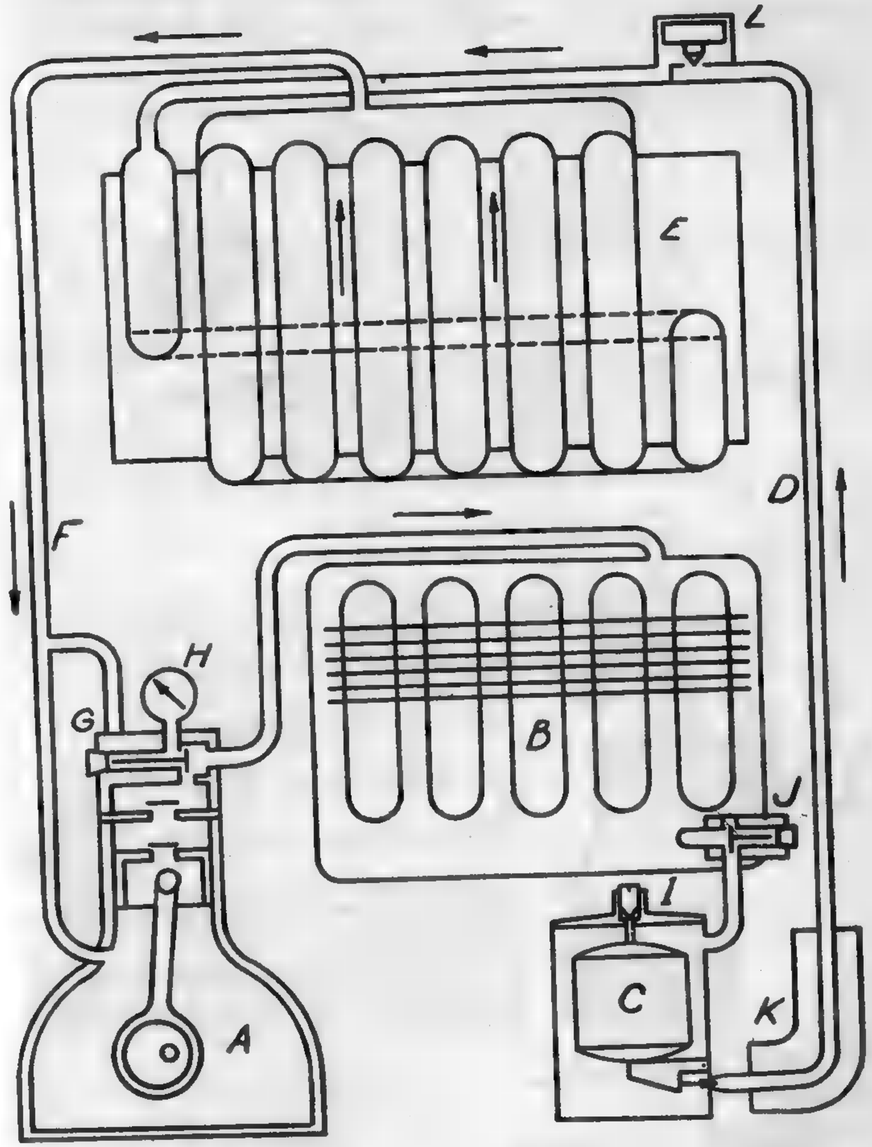


Fig. 44. The 1934-35 Super model Frigidaire cycle
A. Compressor; **B.** Condenser; **C.** High side float and chamber; **D.** Liquid line; **E.** Cooling coil; **F.** Suction line; **G.** Cylinder head and valve assembly; **H.** High pressure gauge opening; **I.** Purging valve; **J.** Liquid service valve; **K.** Liquid line insulation; **L.** Weight check valve

erant control is used with an auxiliary weight check valve. The purpose of this weight check valve is to maintain a pressure in the liquid line of 25 pounds per square inch above that in the cooling unit, preventing the refrigerant from evaporating and freezing before it gets into the cooling unit. The Standard line which is the hermetic type will be explained in Chapter V.

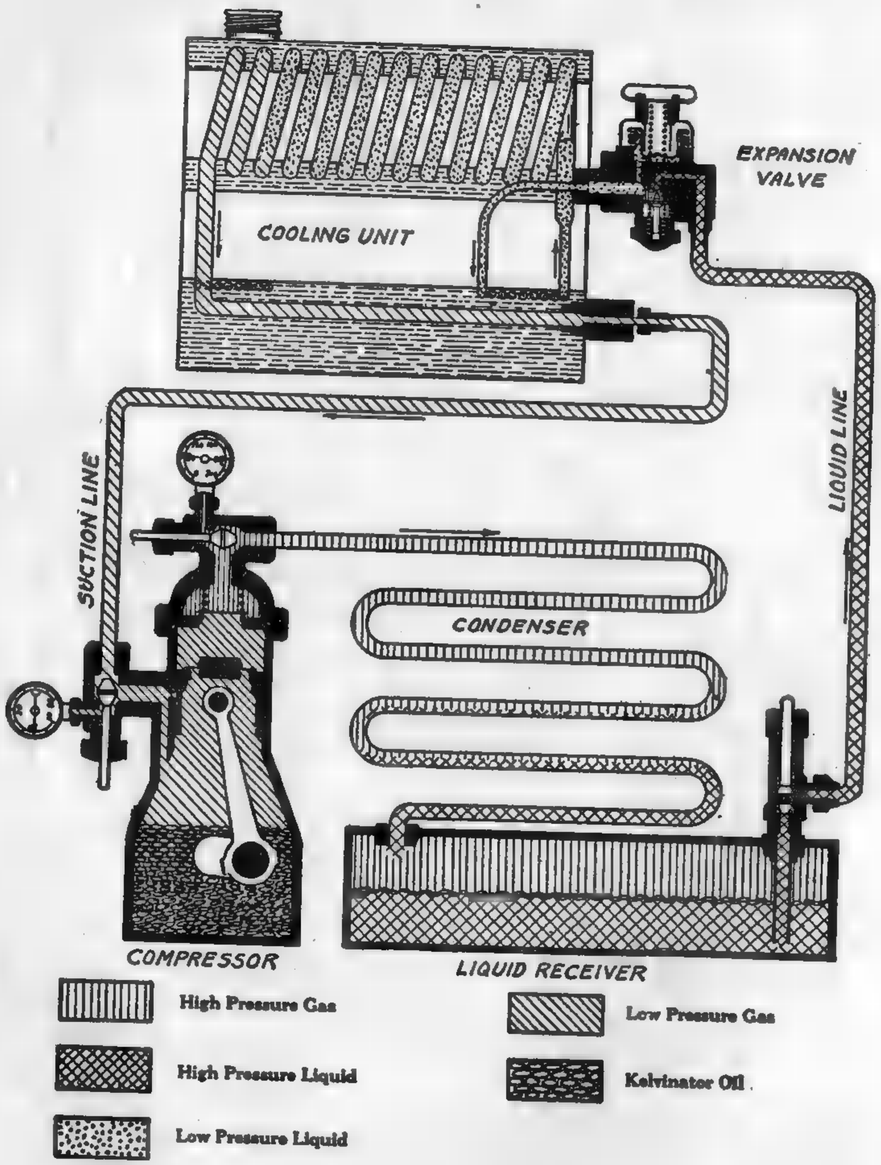


Fig. 45. A typical Kelvinator expansion valve system cycle
(Courtesy of: Kelvinator Sales Corporation)

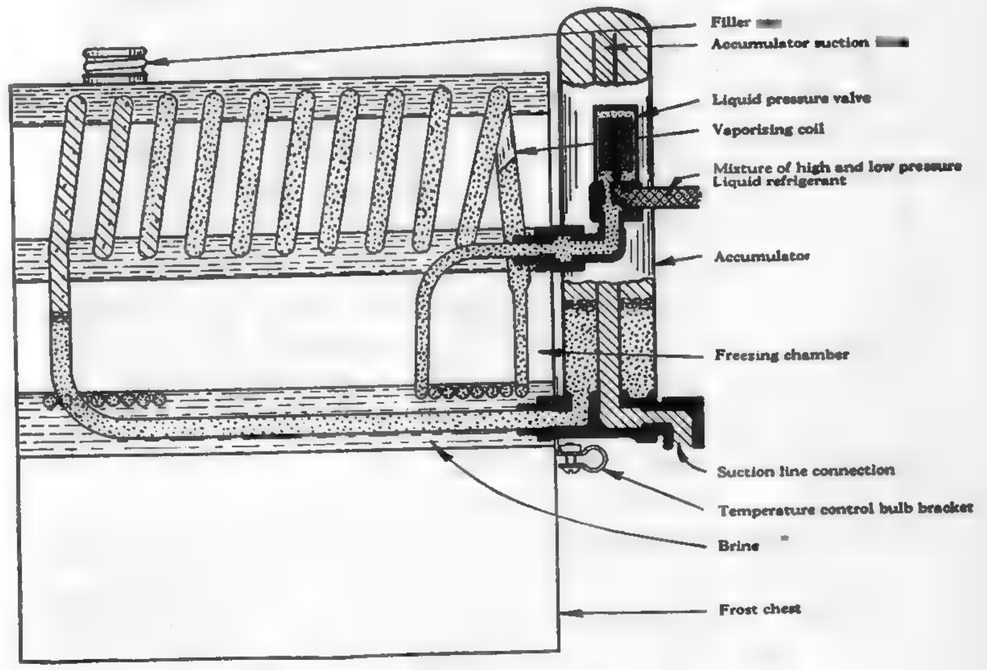


Fig. 46. A Kelvinator cooling unit
(Courtesy of: Kelvinator Sales Corporation)

61. KELVINATOR:

The Kelvinator Corporation of Detroit, Michigan, was one of the first companies to build domestic electrical refrigerators. (See Paragraph 1.) They have produced a great variety of domestic designs. Until 1933, the typical Kelvinator system featured a belt-driven one- or two-cylinder compressor, an air-cooled condenser and liquid receiver mounted in the bottom of the refrigerator cabinet. The re-

frigerant was controlled by an expansion valve and the cooling coil was enclosed in a brine tank.

A thermostatic motor control was mounted on the top of the cooling unit. A typical Kelvinator cycle of this type is illustrated in Figure 45. The cooling unit of one of their recent refrigerators may be easily seen from Figure 46 and the compressor design of their "32" model may be followed in Figure 47. They have had a rather large number of compressor designs and all may be easily serviced. They have used sulphur dioxide as their refrigerant exclusively. The Kelvinator Corporation has used both the flooded type and direct expansion type of cooling unit. The direct expansion type was used in their expensive units. Beginning with 1933, these refrigerators are equipped with a high side float control, located in the liquid receiver in conjunction with an auxiliary weight check valve located in the cooling coil. Some of these use a brine tank (Figure 46), but more use a porcelain finished shell type cooling coil.

Figure 47 shows their newest design in intake valves. The valve, which is mounted in the cylinder head rather than in the piston, increases the efficiency of the compressor and minimizes oil slugging. The exhaust valve is mounted on two screws held down by a bent heavy steel piece backed up by springs. The springs allow the valve to open up wide only when the unit pumps oil. The 1934 and 1935 units retain the high side float and compressor design.

In Figure 46 the refrigerant passes through a shelf coil soldered to the bottom of a one ice tray chamber. This construction enables the Kelvinator refrigerator to obtain very fast freezing on this shelf. The accumulator enables a slight variation in quantity of refrigerant in the cooling coil without decreasing the efficiency of operation. Note that the thermostatic power element control bulb is attached to the outlet of the coil.

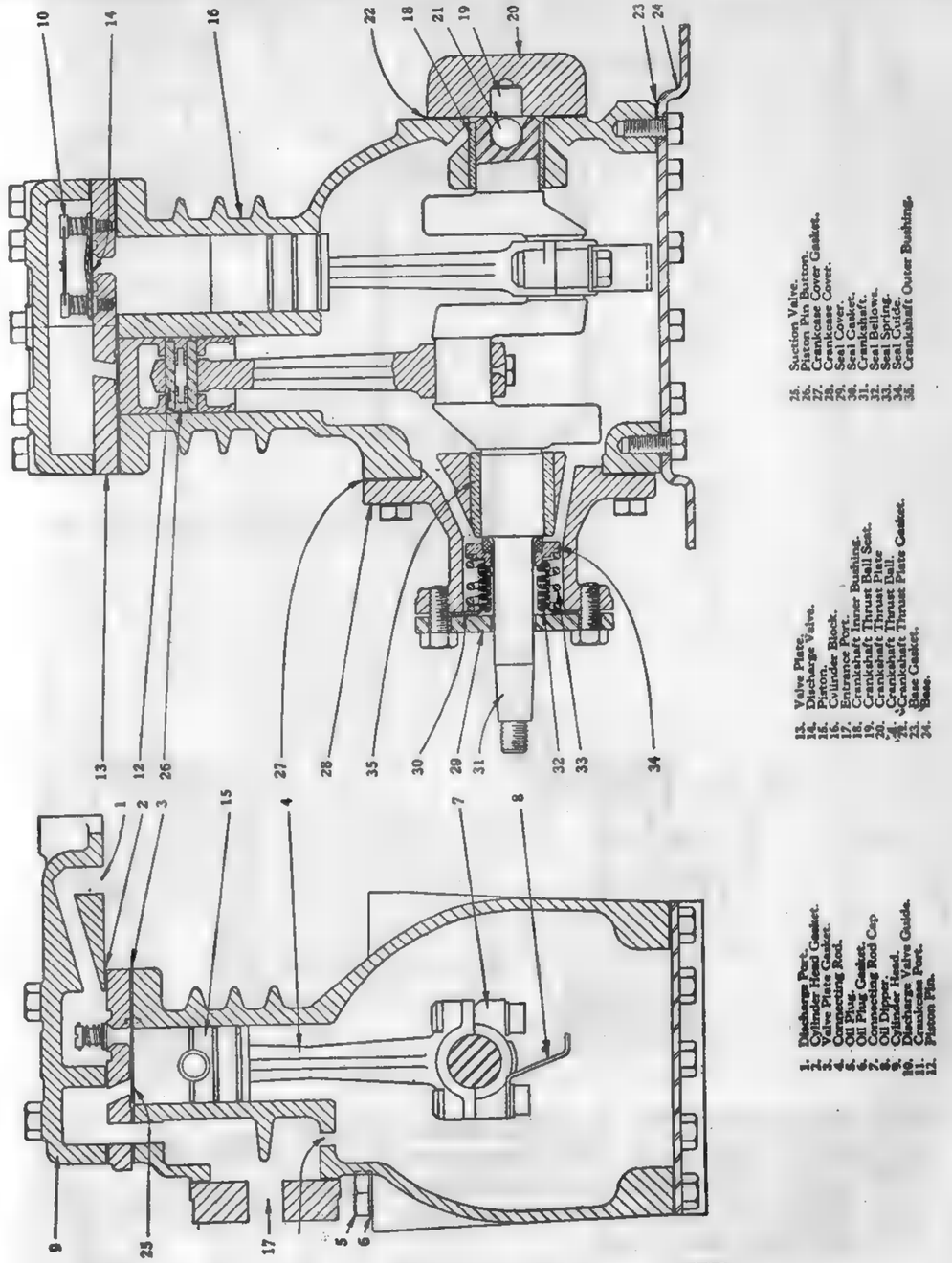


Fig. 47. A Kelvinator compressor, 1932
(Courtesy of: Kelvinator Sales Corporation)

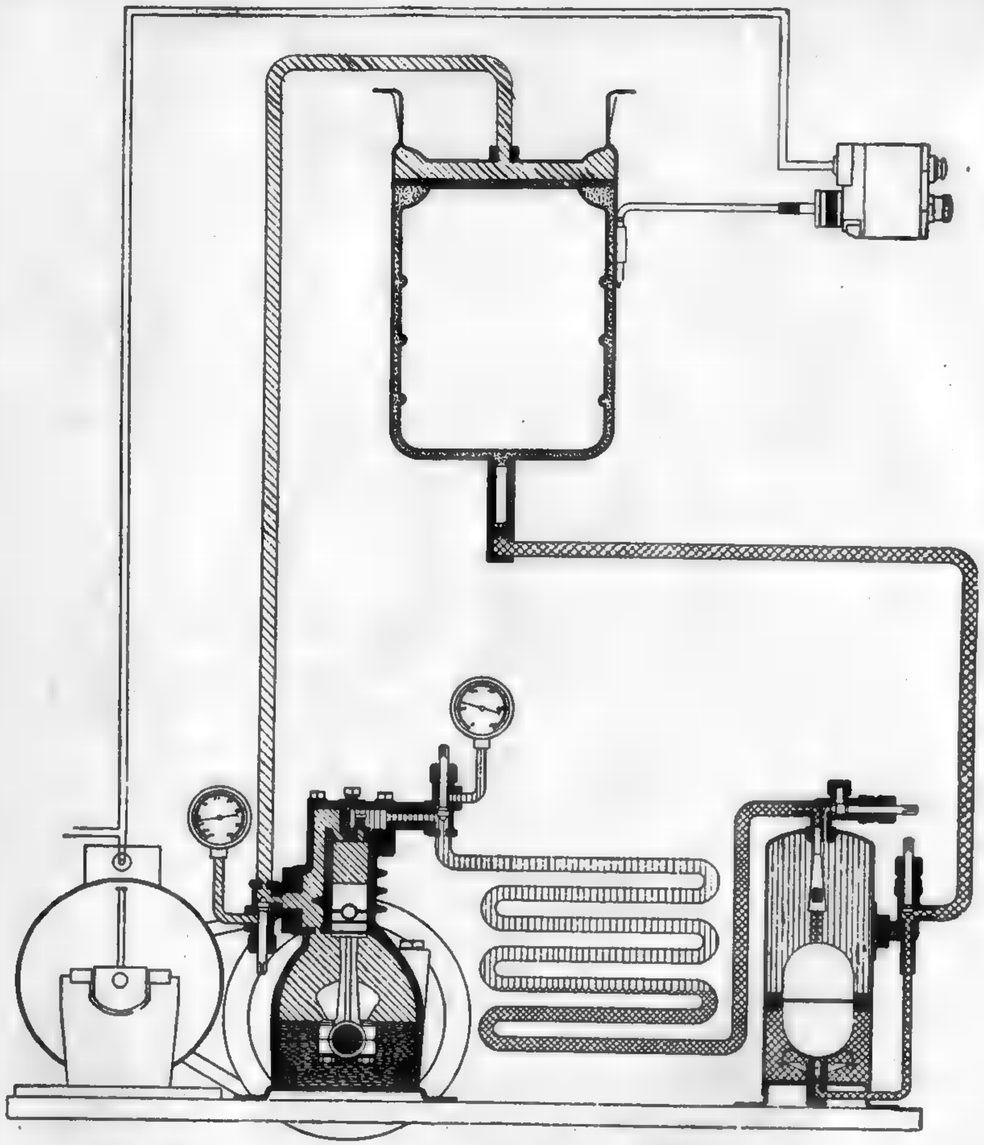


Fig. 48. A Leonard refrigeration cycle
(Courtesy of: Leonard Refrigerator Company)

62. LEONARD:

The Leonard Refrigerator Company is a subsidiary of the Kelvinator Corporation. This company has been building a household electric refrigerator since 1931. It has two features which are not found on many other refrigerators: it has a floor pedal door control in the cabinet, and the refrigerator mechanism itself uses a high side float. Both of these were

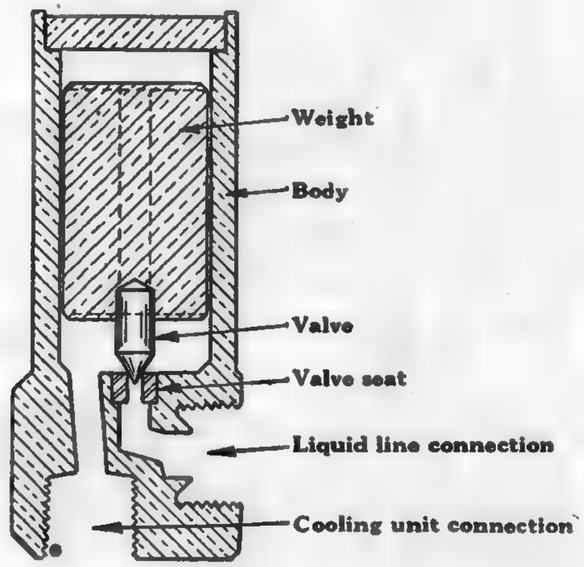


Fig. 49. A Leonard weight valve for high pressure side float system
(Courtesy of: Leonard Refrigerator Company)

unique at the time of their introduction in domestic refrigeration design. Because this high side float method of control is so different from the others, it deserves a detailed explanation.

From the diagram (Figure 48) it is seen that the refrigerator is equipped with a float located in the liquid receiver, and that in the base of the cooling unit a weight float is used. It functions as follows: When enough refrigerant has con-

densed in the liquid receiver, the float opens the line and allows the liquid refrigerant to flow up to the cooling unit, but it cannot flow into the cooling unit until there is a difference in pressure of twenty-five pounds between the high pres-

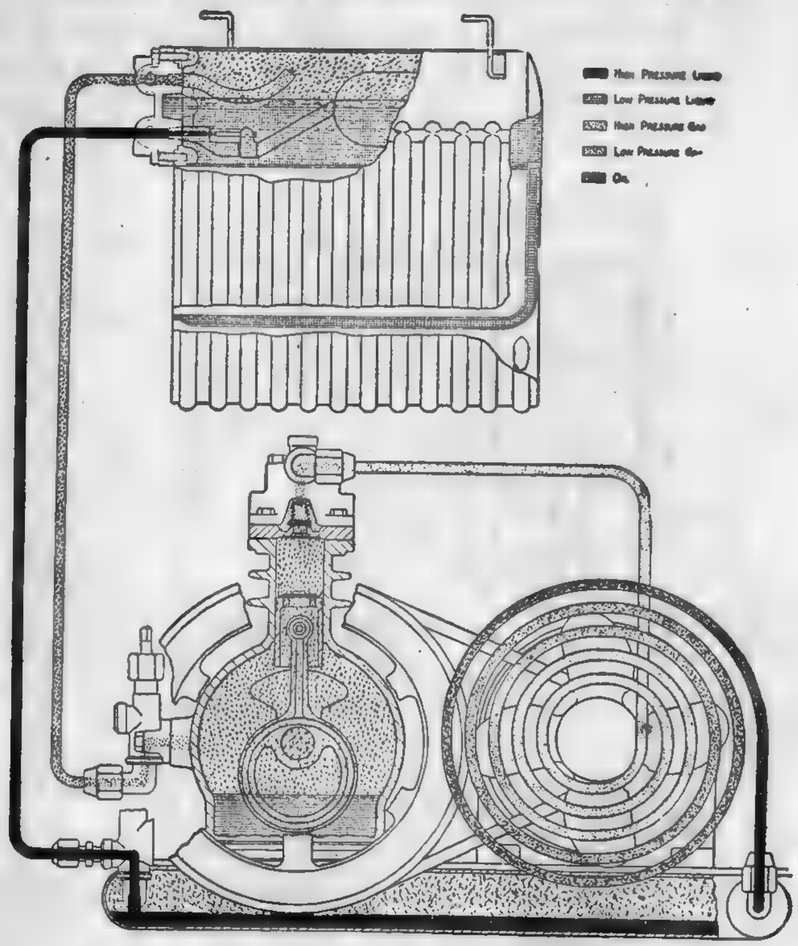


Fig. 50. The Mayflower cycle
(Courtesy of: Trupar Manufacturing Company)

sure side and the low pressure side. This difference in pressure will raise the meter valve or weight valve located in the rear of the cooling unit and allow the refrigerant to flow into the

low pressure side. Figure 49. This system may be said to have three pressures, the low pressure and the high pressure as usual; but there is also an intermediate pressure located in the liquid line between the weight valve and the float valve in the receiver tank, and this intermediate pressure is never

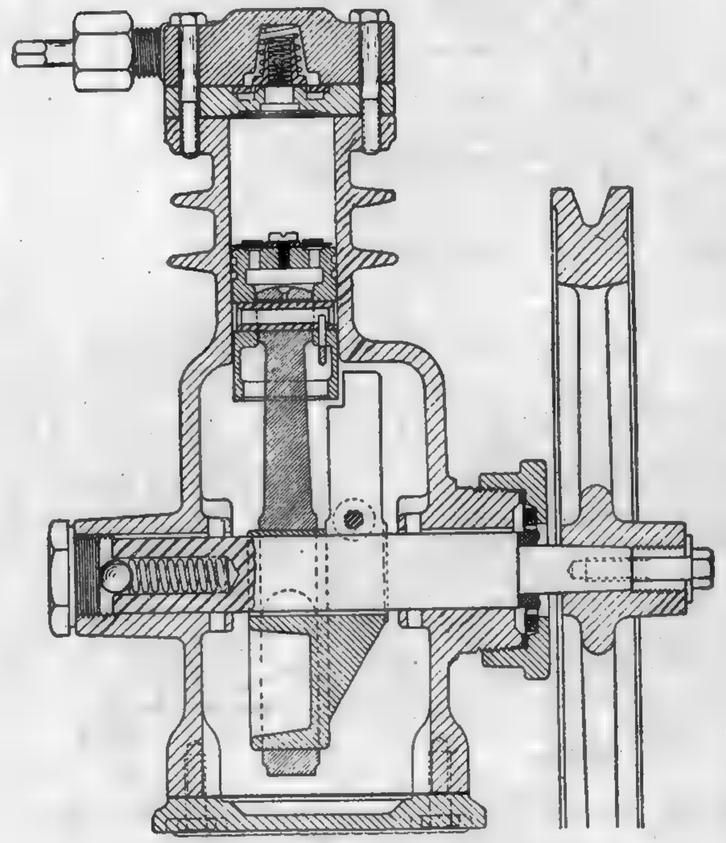


Fig. 51. The Mayflower compressor
(Courtesy of: Trupar Manufacturing Company)

more than 25 pounds over the low side pressure. The system uses sulphur dioxide as the refrigerant. The compressor design may be followed from the cycle diagrammatic sketch and it will be noted that it has an unusual feature in that the

location of the intake valve of the compressor is in the cylinder head and not in the head of the piston. See Figure 48. Note the extra service purging valve located in the top of the

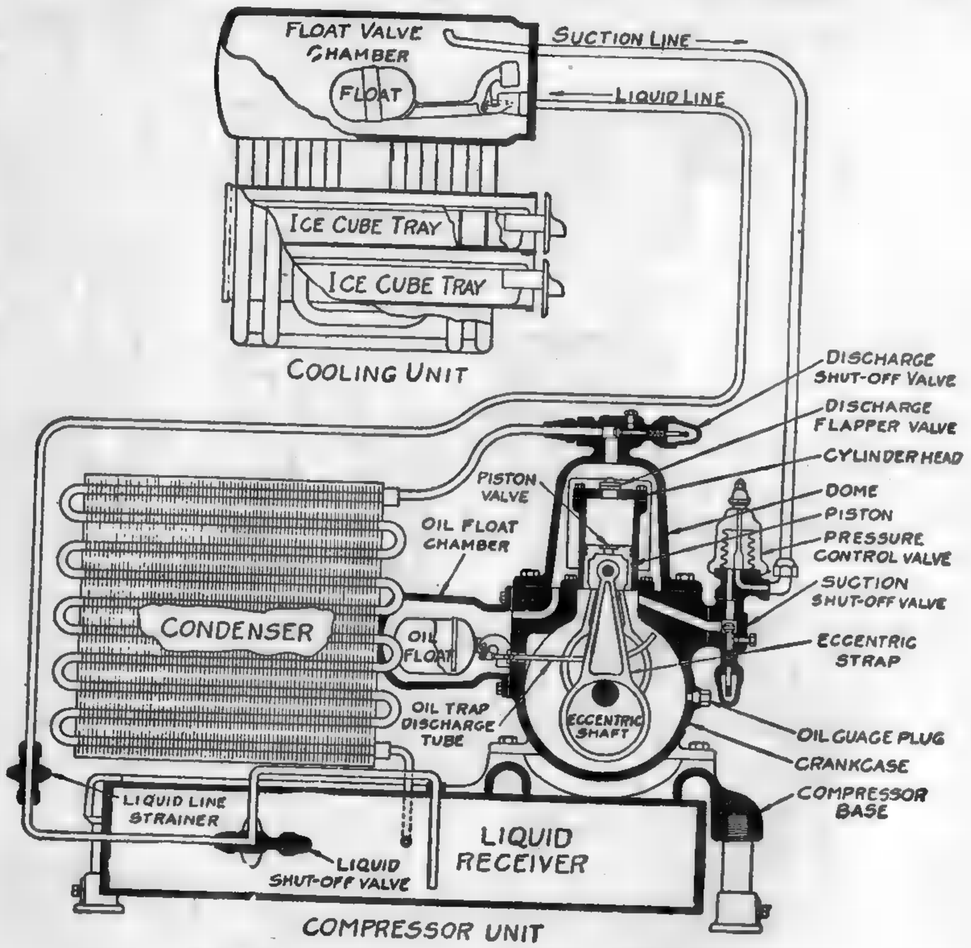


Fig. 52. An Ice-O-Matic refrigeration cycle
(Courtesy of: Williams Oil-O-Matic Heating Corporation)

liquid receiver. This valve is used for purging non-condensable gases from the float chamber. The cooling unit style of construction is called the shell type.

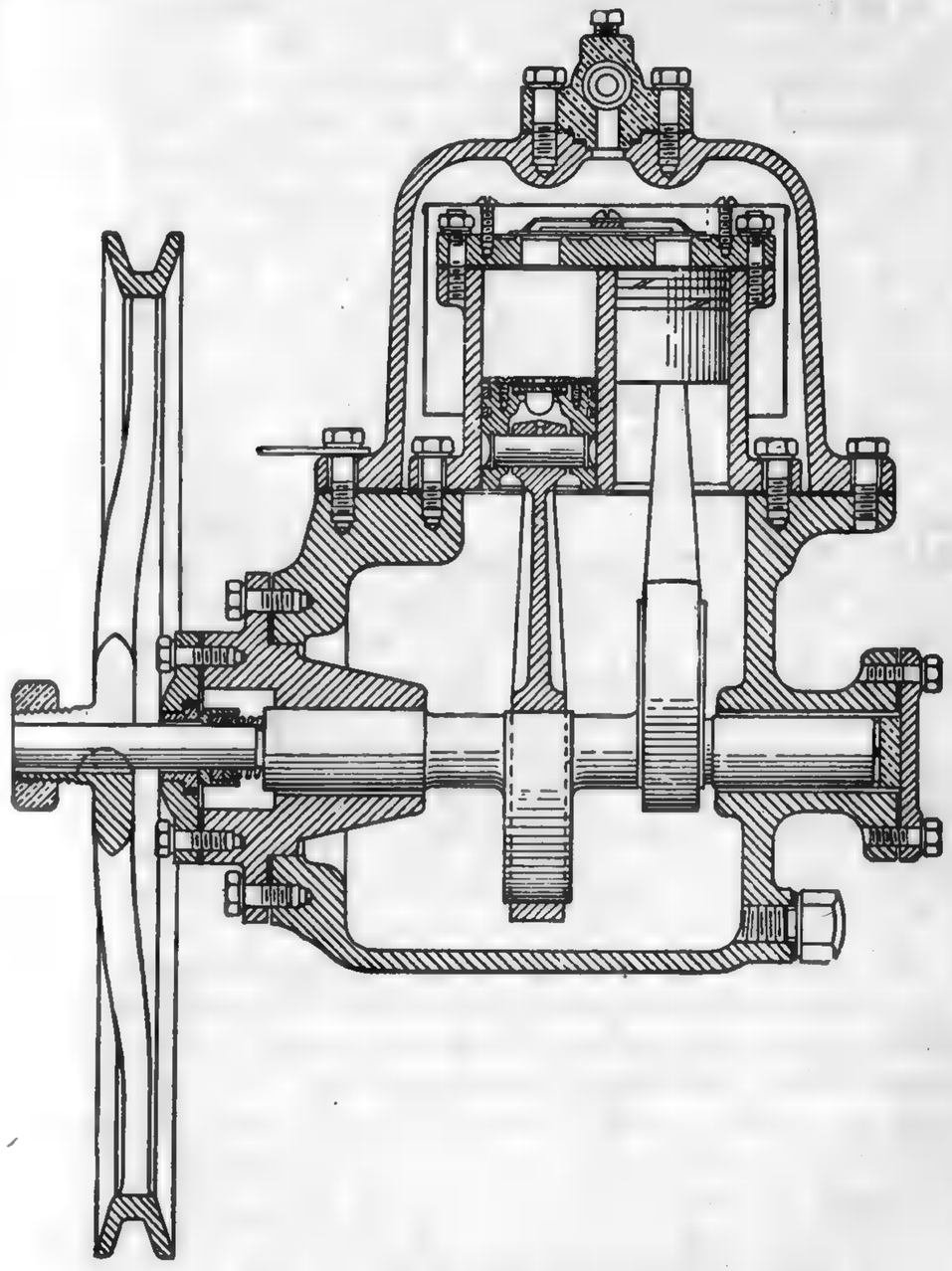


Fig. 53. An Ice-O-Matic compressor
(Courtesy of: Williams Oil-O-Matic Heating Corporation)

63. MAYFLOWER:

The Trupar Manufacturing Company, recently of Dayton, Ohio, and now located in Detroit, Michigan, has produced a domestic refrigerator, the Mayflower, along with its complete line including commercial and apartment house installations. The cycle is conventional as may be seen from Figure 50. It has a unique condenser in that it is constructed on the spiral principle, and in the old models it was cooled by a fan located on the compressor. On the new models, however, it is cooled by a fan located on the motor. The compressor details may be found in Figure 51. It has a flooded cooling unit, porcelain finished, and uses sulphur dioxide as the refrigerant. The sylphon seal in the compressor varies a little from conventional designs as may be seen from Figure 51. Notice in particular the intake and exhaust valves; see how the piston pin is attached, and how the eccentric is attached to the crankshaft. The cooling coil is equipped with servicing valves built into the header. These valves are capped to prevent corrosion of the valve stem and an external packing nut is used. The 1935 model uses a dry cooling coil, and the refrigerant is methyl chloride.

64. ICE-O-MATIC:

The Williams Oil-O-Matic Company, Bloomington, Illinois, builds domestic refrigerators called the Williams Ice-O-Matic which use methyl chloride as the refrigerant and have a conventional cycle as illustrated. Figure 52.

One unique feature of the Ice-O-Matic is the oil trap built into the compressor to prevent the oil pumped out of the compressor from going over into the other parts of the system. This is accomplished by providing a dome-shaped receiver over the cylinder which receives the discharge from the compressor. An inverted cylindrical baffle inside the dome

and surrounding the cylinder collects the oil pumped by the compressor. This oil then flows to a float-controlled oil reservoir illustrated at the left of the compressor crankcase. As the oil level rises, the float will be lifted and a needle valve opens allowing the oil to flow back into the crankcase of the compressor. The oil will flow into the crankcase due to the pressure difference between the two chambers, as high pressure is on the surface of the oil in the oil reservoir and low side pressure exists in the crankcase. This device is used because oil dissolves readily in methyl chloride and is heavier than the liquid refrigerant. If adequate provision is not made to separate the oil from the refrigerant, it would tend to collect below the refrigerant in the cooling coil and interfere with its operation. In studying the illustration one should note that the low side float in the cooling coil is counterbalanced because of the low specific gravity of the refrigerant (methyl chloride).

A low side pressure control, built on one end of the suction service valve, prohibits excessive low side pressure from accumulating in the crank case, which would make it difficult for the compressor to start. The service valves used in the system are of the capped type preventing corrosion of the valve stems. The flywheel is attached to the crankshaft by a split hub clamping arrangement and a Woodruff key. The crankshaft seal is constructed with a brass and graphite seal ring pressed on the crankshaft against a spring which in turn holds a synthetic rubber gasket against the seal ring. Figure 53. This ring rotates against a hardened steel ring pressed into the compressor shaft clamping disk. This construction is easy to service.

65. REVIEW QUESTIONS:

The answers to the following questions may be found on page 808.

1. What is the definition of a conventional refrigerating mechanism?
2. What kind of belts are used with these machines?
3. Of what materials are cooling coils made?
4. Name the popular types of refrigerant controls?
5. How is the condenser cooling fan usually driven?
6. Where is the liquid receiver service valve located on the older Copeland refrigerators?
7. Why does not the Crosley use a liquid receiver?
8. What is the most popular method of attaching the flywheel to the crankshaft?
9. Why are the suction lines run to the crankcase (directly or indirectly)?
10. Referring to Figure 43 how is the condenser cooled?
11. Referring to Figure 46 what is the purpose of the accumulator?
12. Locate and identify by number the surfaces closed with gaskets in Figure 47.
13. Why is a weight valve used in connection with some high side float control mechanisms?
14. Where is the intake valve located in the Mayflower compressor?
15. Referring to Figure 51 does the compressor have piston rings? How many?

CHAPTER V

DOMESTIC ROTARY AND HERMETIC COMPRESSION CYCLE REFRIGERATORS

There are several refrigerators on the market which differ rather materially from the conventional refrigerators described in Chapter IV, and their arrangement and design warrant a rather detailed explanation.

These refrigerators either embody a rotary compressor, or are hermetic, or both. The term "hermetic" implies that the motor and compressor are sealed in a refrigerant-tight container. Such an arrangement eliminates crankshaft seals and stuffing boxes. This makes servicing these refrigerators somewhat different than servicing conventional machines. Refer to Chapter XIX for detailed specifications for all refrigerators.

66. NORGE:

One which corresponds rather closely to the conventional design is built by the Norge Corporation of Detroit, Michigan. Its construction differs radically only in the design of the compressor. Figure 54.

Instead of the reciprocating compressor, the Norge refrigerator uses a rotary mechanism which is called the "Rollator." It consists of an eccentric crankshaft, enclosed in a circular housing with a free sleeve mounted on the eccentric of the crankshaft. It has two ports located in the housing and separated by a movable blade which is always in contact with the sleeve. Figure 55. The duty of this compressor is identical to that of the reciprocating type and it performs as follows: The crankshaft rotating creates a space on the suction side of the blade allowing gas to enter this space through the suction port. As it continues to roll around, it pushes this quantity of gas around the chamber, at the same time

compressing it until the gas is pushed around to the other side of the blade. When the pressure gets high enough it is

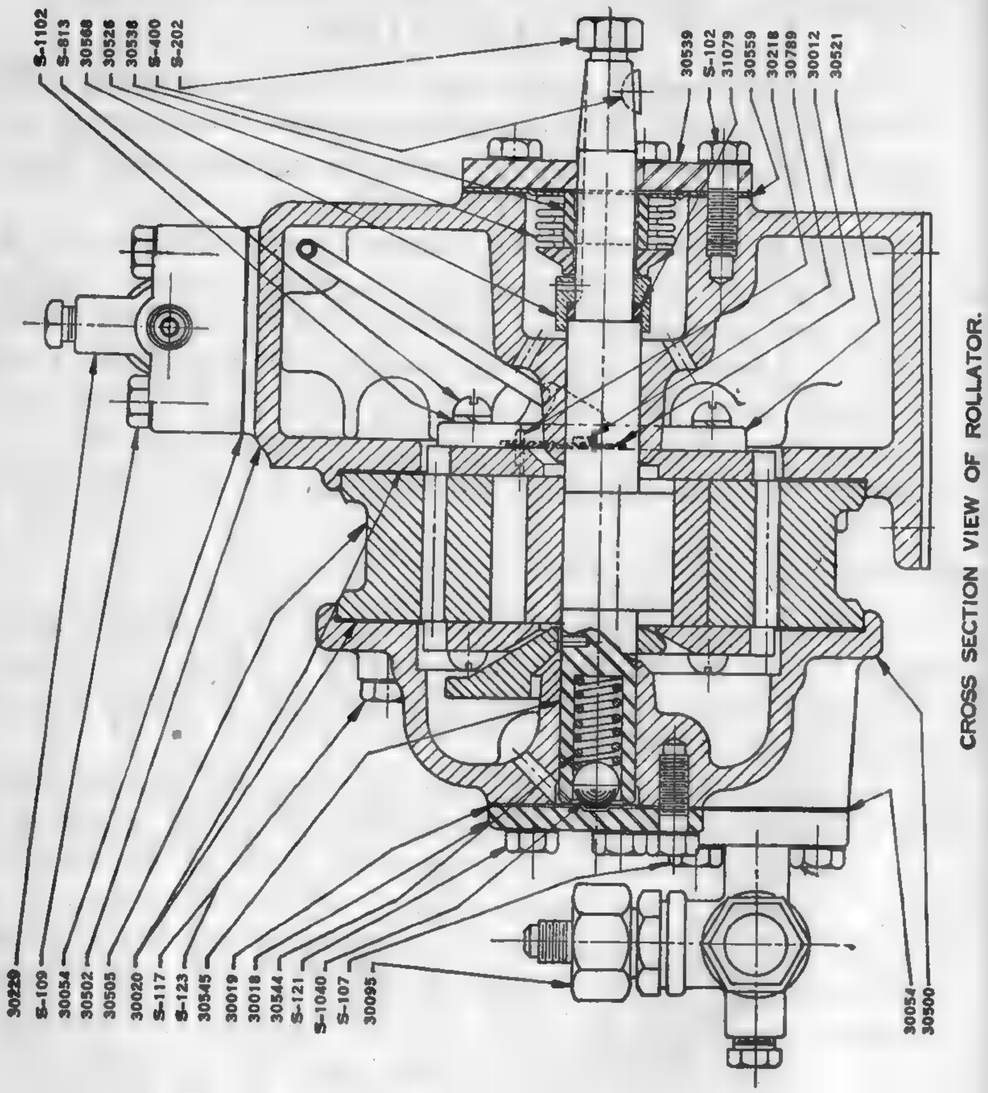


Fig. 55. The Norge Rollator compressor, 1932
(Courtesy of: Norge Corporation)

discharged out of the exhaust port located on this side of the blade. Figure 56.

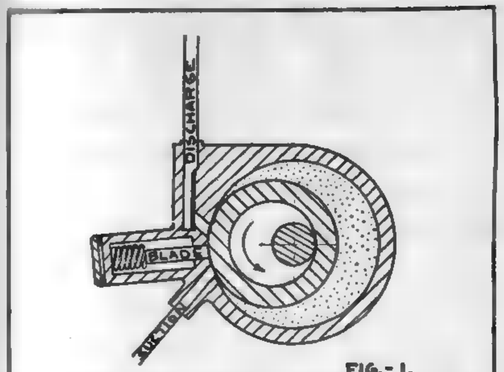


FIG.-1.
CYLINDER FULL OF GAS AT START OF COMPRESSION.

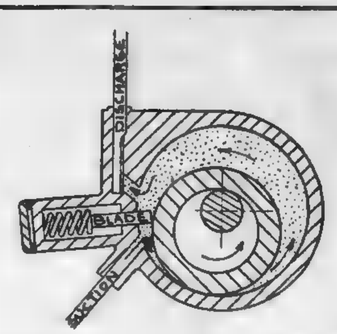


FIG.-2.
COMPRESSION STARTED AND BEGINNING OF SUCTION STROKE.

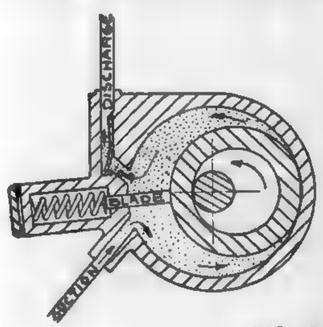


FIG.-3.
DISCHARGE AND SUCTION STROKES HALF COMPLETED.

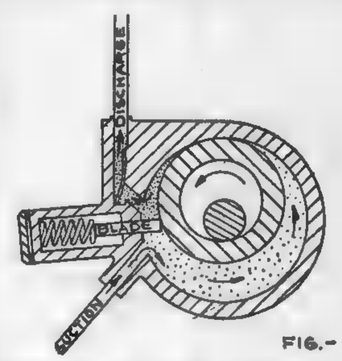


FIG.-4.
DISCHARGE VALVE OPEN ON COMPRESSION STROKE.

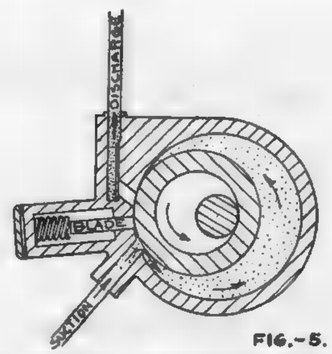


FIG.-5.
DISCHARGE AND SUCTION STROKES COMPLETED.

Fig. 56. The operation of the Norge compressor
(Courtesy of: Norge Corporation)

The high pressure gases are fed to a storage chamber in the top of the compressor which is also used as the oil reservoir. It may be noted here that the crankshaft opening to the belt wheel is located in this chamber and therefore the compressor seal is a high pressure seal which principle differs materially from the reciprocating compressor design.

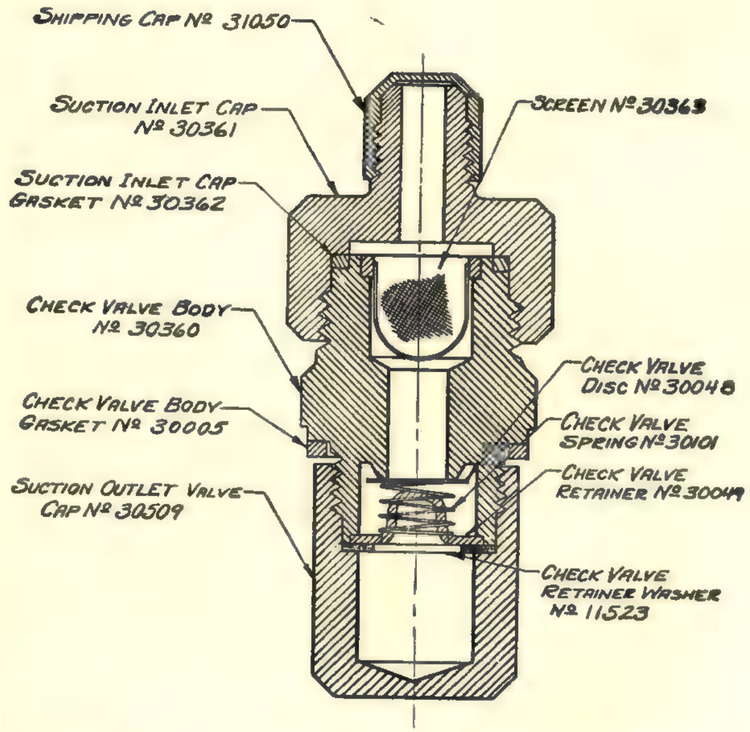

Shipping Cap Nº 31050
Suction Inlet Cap Nº 30361
Screen Nº 30363
Suction Inlet Cap Gasket Nº 30362
Check Valve Body Nº 30360
Check Valve Disc Nº 30048
Check Valve Body Gasket Nº 30005
Check Valve Spring Nº 30101
Suction Outlet Valve Cap Nº 30509
Check Valve Retainer Nº 30049
Check Valve Retainer Washer Nº 11523

Fig. 57. The Norge check valve located at the suction service valve
(Courtesy of: Norge Corporation)

Referring to Figure 55 it will be noted that part No. 30505 is the housing of the compressor chamber proper which must be very accurately aligned when the unit is assembled. Part No. 30568 is a bronze ring pressed on the shaft with a synthetic rubber gasket No. 31079 to perfect the seal. The hardened and ground steel bellows ring presses against this shoul-

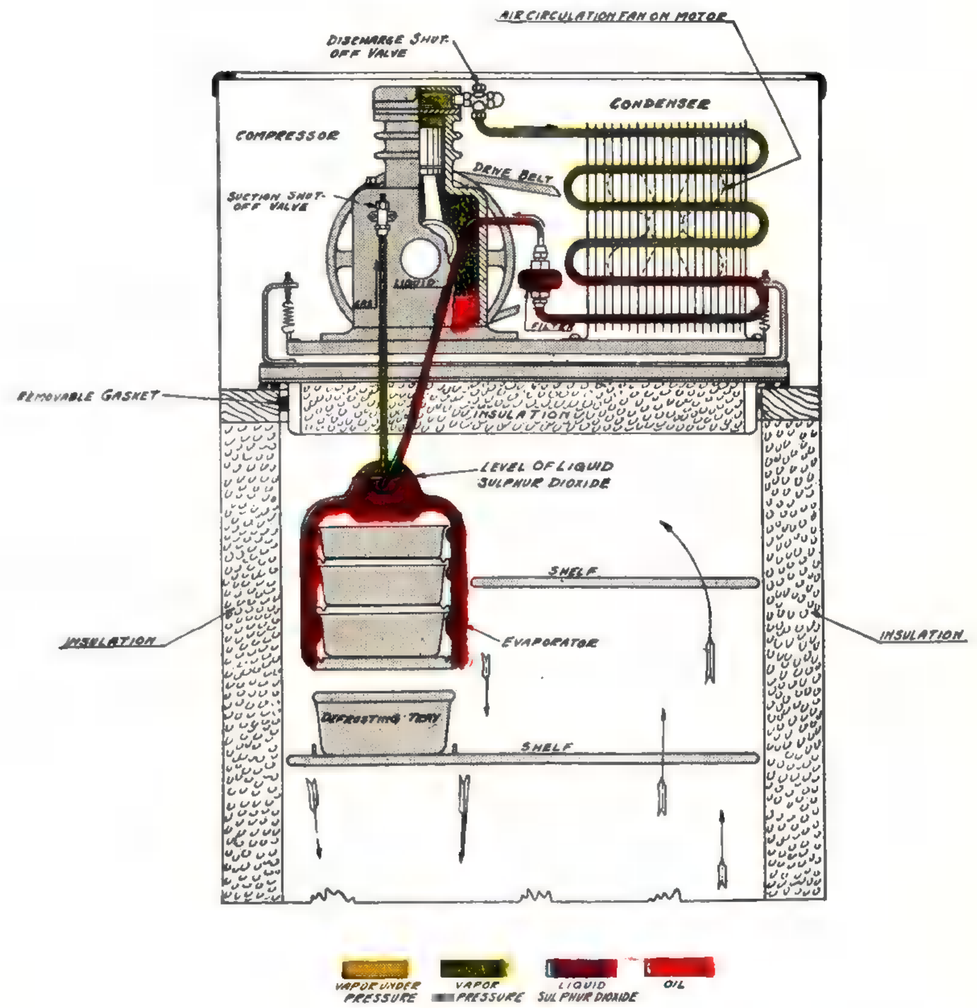


Fig. 38. The Crosley unit
(Courtesy of: The Crosley Radio Corporation)

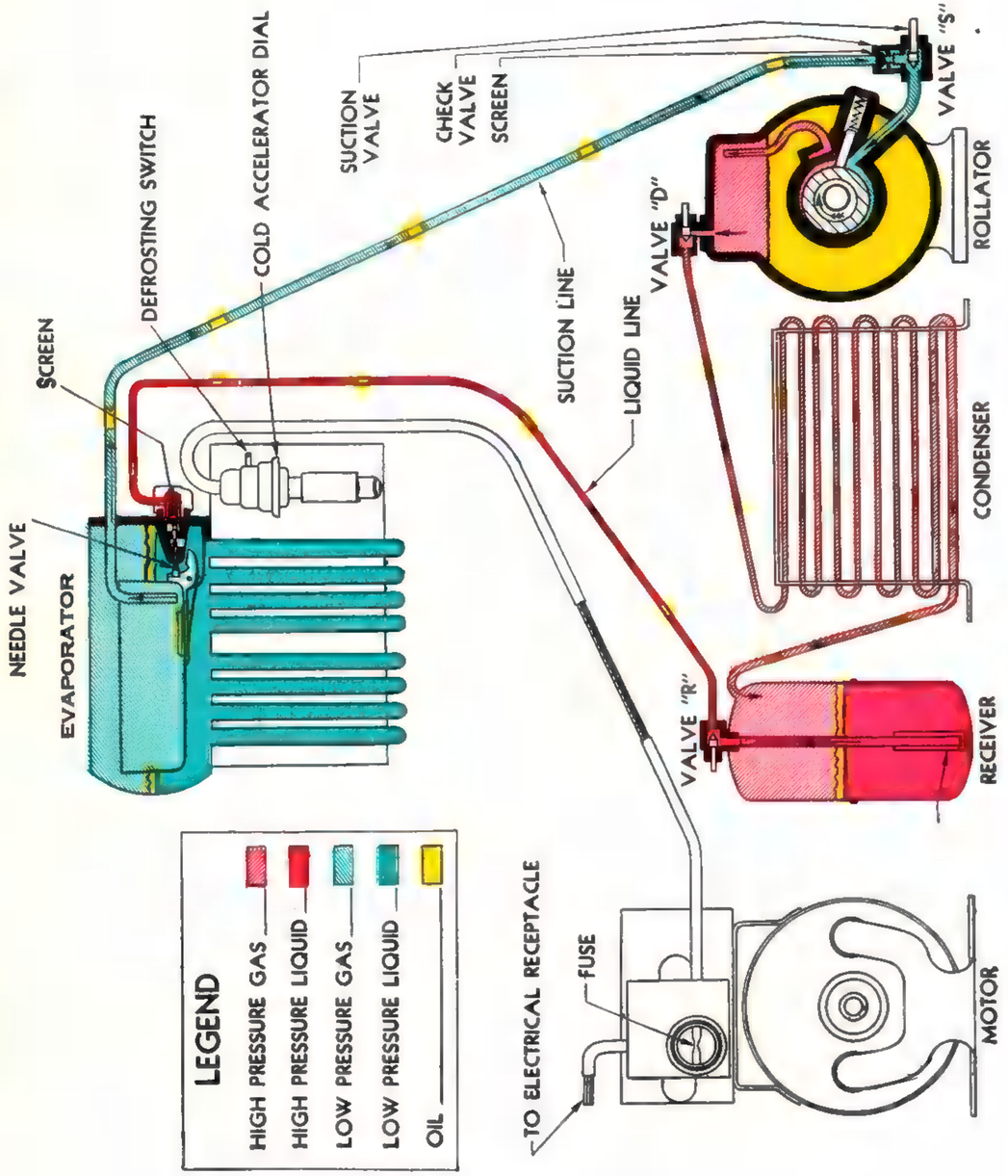


Fig. 54. The Norge cycle (1932)
(Courtesy of: Norge Corporation)

der to make the crankshaft seal. No. 30012 is the flapper exhaust valve which is located in the discharge opening of the compressor, while No. 30095 is the check valve housing

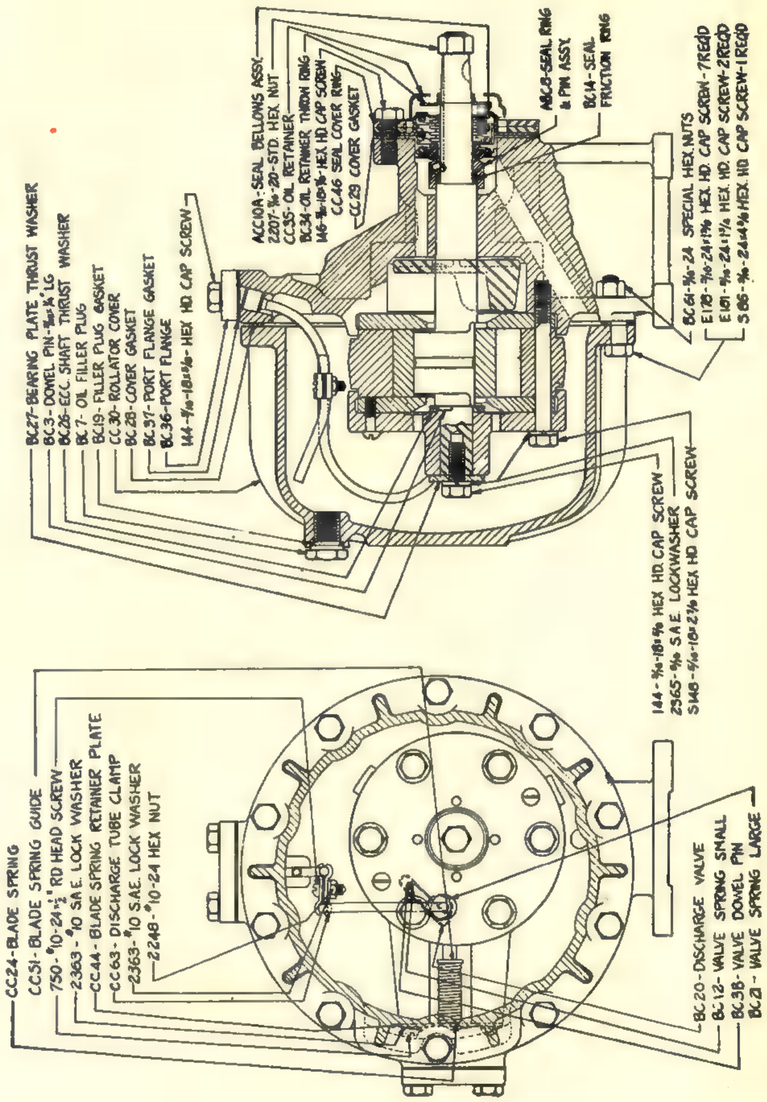


Fig. 58. Norge Rollator, 1935
(Courtesy of: Norge Corporation)

mounted on the suction service valve. The discharge service valve is No. 30229.

This refrigerator is equipped with service valves placed in the conventional manner and the cooling unit is usually the low side float type with an open pan float. The direct expansion type cooling unit is also used. The receiver and air-cooled condenser are identical to those used in the reciprocating units.

The Norge has a check valve in the suction line so that when the compressor is not running, the oil in the compressor and the high side pressure cannot back up into the cooling unit. Figure 57.

The new Norge refrigerator (1935) operates much the same as illustrated in Figure 54. The new Rollator compressor has a housing surrounding the compressor which serves as an oil reservoir. Figure 58.

The float in the flooded cooling coil is a ball type instead of the open pan type used in previous models. A wick arrangement in the float chamber is attached to the open end of the suction line and provides a means of removing oil from the surface of the refrigerant. The liquid receiver is mounted above the condenser and a torque reaction type motor is used which automatically keeps the belt tight. Figure 59. Note the location of the check valve and the screens on each side of the check valve.

67. THE MAJESTIC:

A refrigerator somewhat similar to the Norge in construction, but which is modified to the extent that it is a hermetically sealed unit was manufactured by the Grigsby-Grunow Company. Figure 60. It used a rotary compressor. This compressor is directly driven and an extra motor is used to give forced air circulation over the condenser. Figure 61

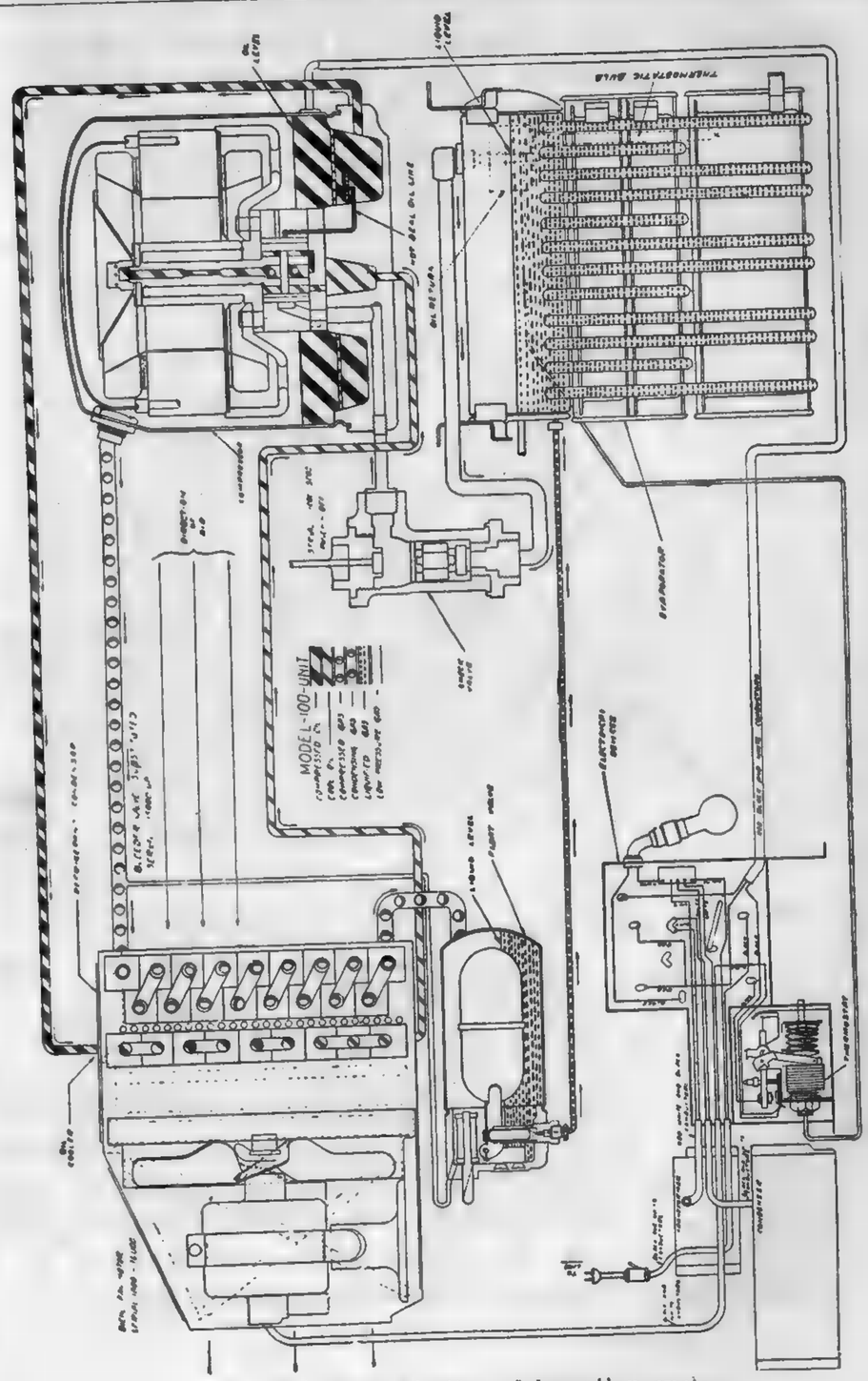


Fig. 60. The Majestic refrigeration cycle
(Courtesy of: Grigsby-Grunow Company)

illustrates a cross section of this compressor. Referring to Figure 60 one should notice the high side float, the weight check valve, and the special auxiliary condenser for cooling the oil. To prevent condensation of refrigerant in the dome of the compressor, the complete dome is insulated to keep this part warm. Note how the high side float chamber is

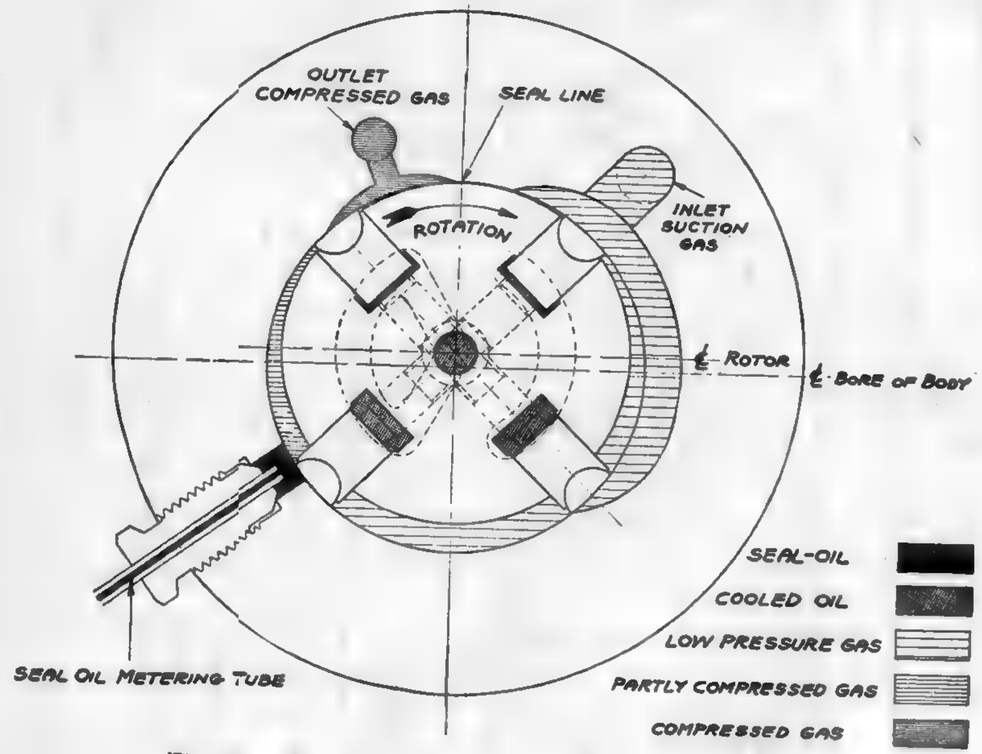


Fig. 61. The Majestic hermetic rotary compressor
(Courtesy of: Grigsby-Grunow Company)

drained to prevent the accumulation of non-condensable gases in it. One of the first designs of the Majestic used a conventional, rotary, belt-driven compressor, located in the base of the cabinet. This compressor differed from the usual rotary compressor in that the sliding blade was attached to the eccentric sleeve by means of a ball and socket joint.

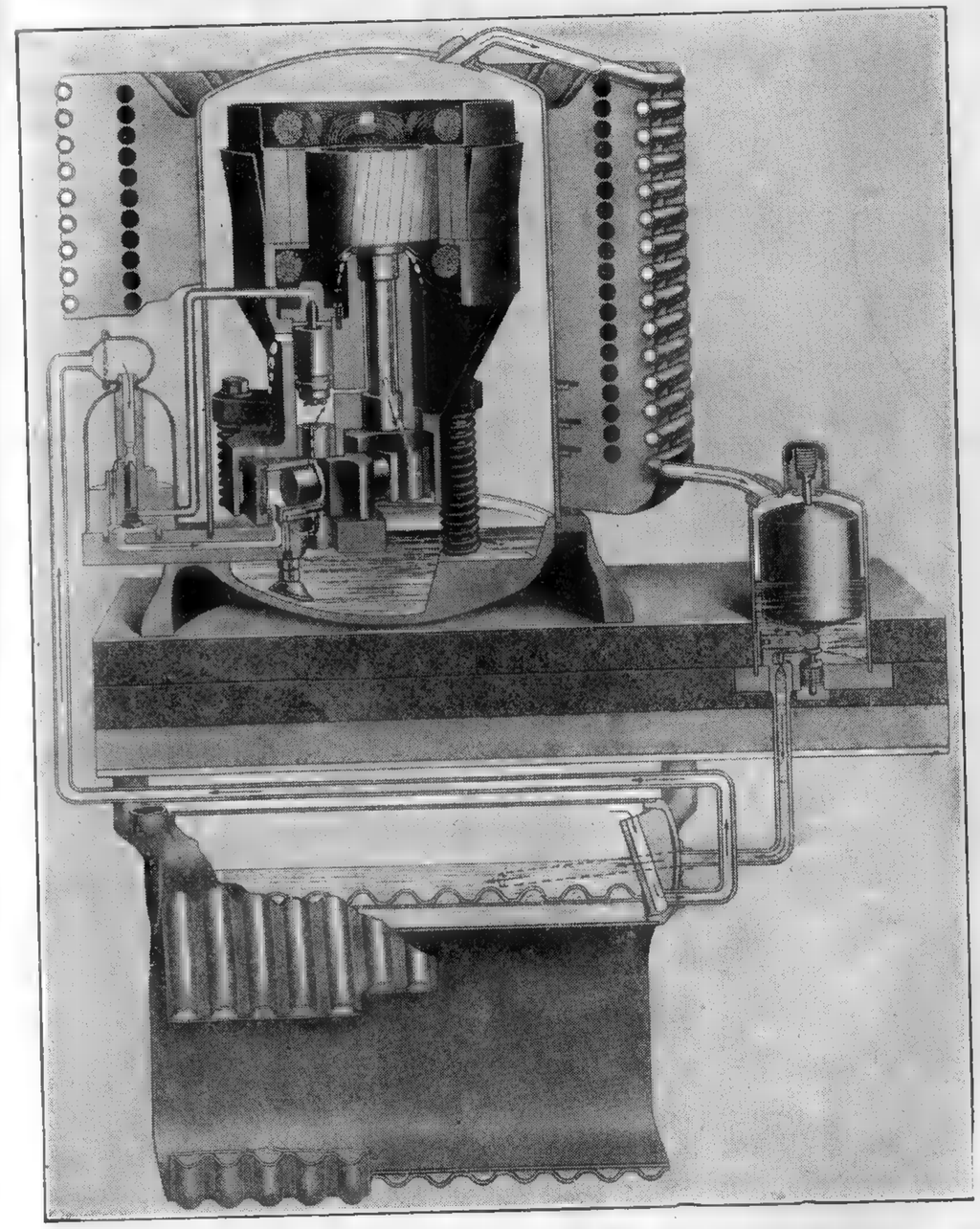


Fig. 62. The General Electric Hermetic cycle (1927 to 1934)
(Courtesy of: General Electric Company)

When speaking of a hermetically sealed unit, a unit that has all welded or soldered joints is implied. It is not sup-

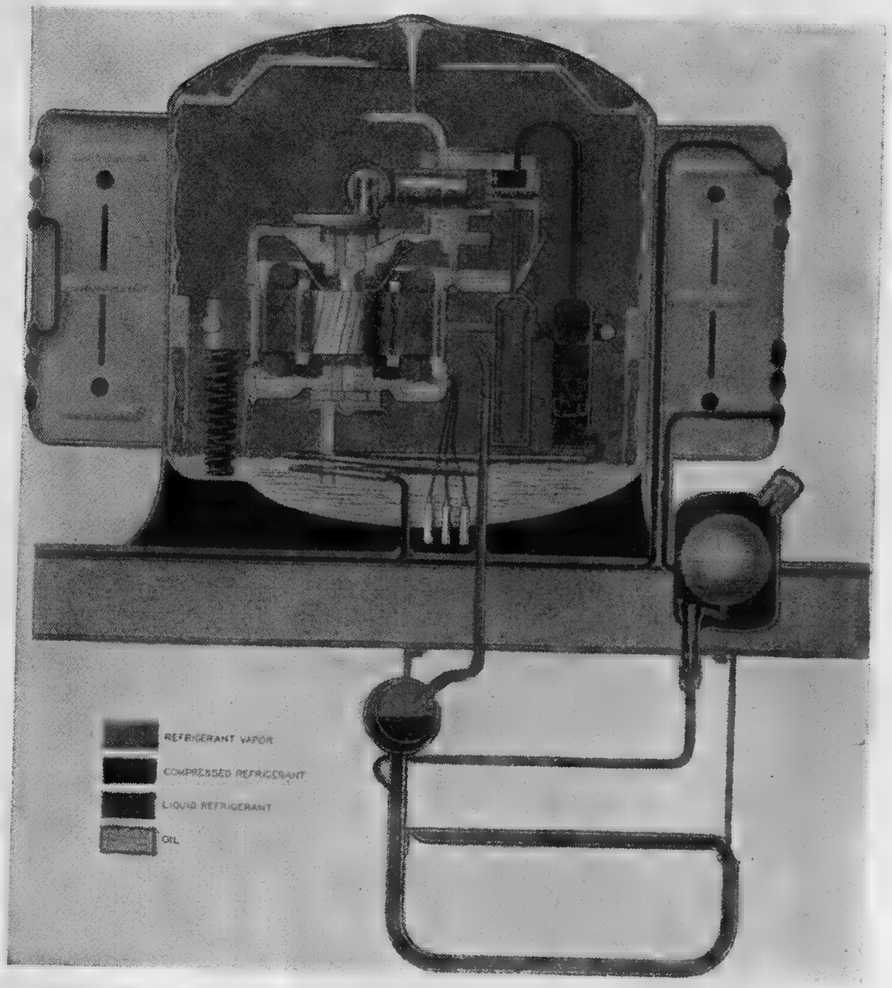


Fig. 68. The General Electric Hermetic compressor (1935)
(Courtesy of: General Electric Company)

plied with valves or any mechanical joints which will give it a chance to lose its refrigerant or take in air.

68. GENERAL ELECTRIC:

The General Electric is a very popular hermetically sealed

refrigerator which has a monitor-top design. This refrigerator incorporates a horizontal, reciprocating compressor using an oscillating cylinder and it is directly driven by a specially constructed motor. Figure 62. The whole mechanism is completely sealed-in. The cooling unit is the flooded type with a remote high side float control.

One feature of the General Electric is that to relieve the starting load of the electric motor an oil pressure float is used to by-pass the pressure when the mechanism starts in order to relieve the load on the motor until it attains full speed. Figure 62.

The oil pressure plunger located over the piston settles when the compressor stops. This permits the high pressure in the dome to go down the tube, raising the check valve located just under the suction line screen. This check valve will keep the suction line closed until the compressor starts again and builds up an oil pressure. Naturally, the checking of the suction line relieves the starting load on the compressor and motor. Another innovation in refrigeration used in this system is a very small heating element (electric), located in the oil reservoir. This heating element frees the oil of refrigerant before it is used to lubricate the parts. This hermetic unit was put into production by the General Electric Company in 1926 and was continued until 1934.

The new General Electric models began to vary from the above standard in 1932 when the company produced a flat top model. This unit was also hermetic, but of a bolted construction and used a horizontal reciprocating single cylinder compressor. A high side float was also used in this unit (the General Electric Company has never varied from this type of refrigerant control). In 1934 the company produced a vertical, motor, rotary compressor in the monitor top design, using methyl formate as the refrigerant. This company also

made a chest cabinet (lift-top) hermetic model. The 1935 monitor top has the compressor (reciprocating) located over the motor, and the dome is on the low pressure side of the

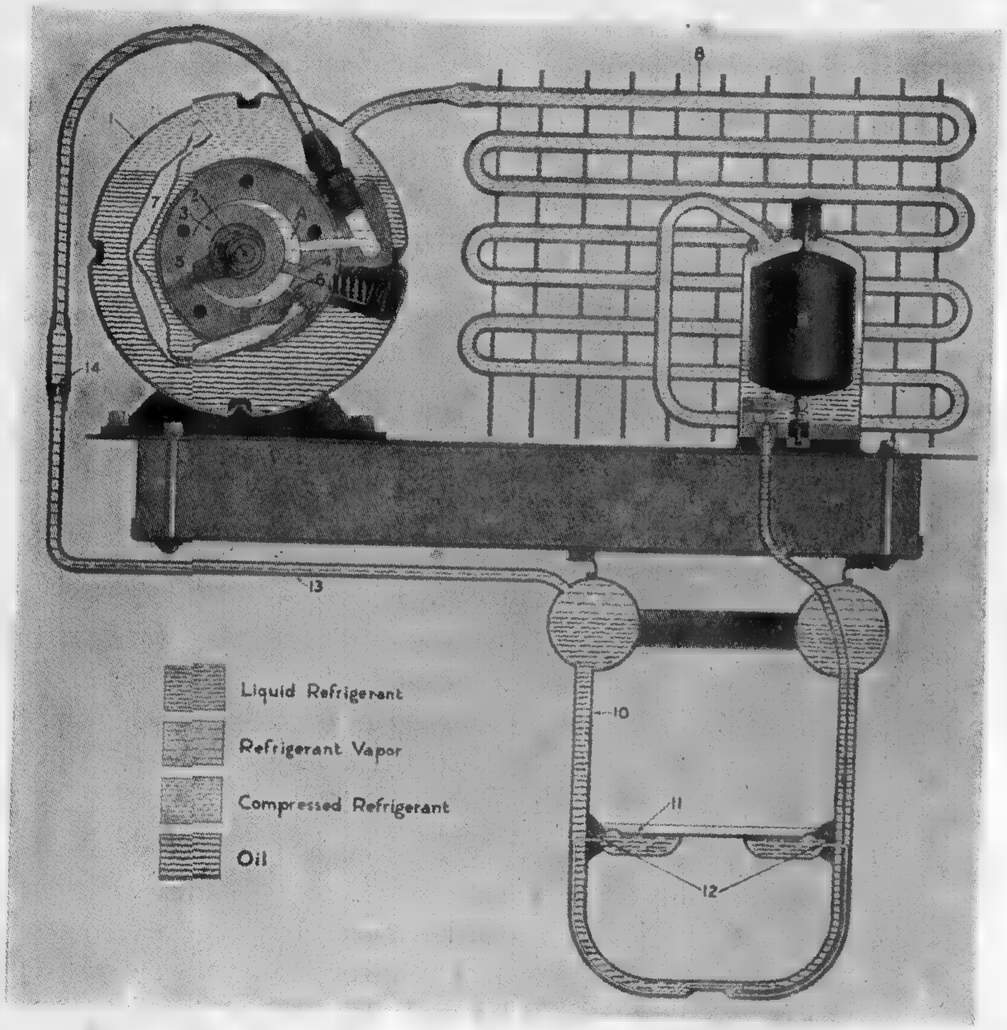


Fig. 64. The General Electric Flat Top rotary compressor cycle
1. Compressor; 2. Compressor shaft; 3. Piston; 4. Blade; 5. Cylinder; 6. Discharge valve; 7. Acoustic filter; 8. Finned tube condenser; 9. Float; 10. Cooling unit; 11. Freezing shelf; 12. Injectors; 13. Suction line; 14. Check valve
(Courtesy of: General Electric Company)

system. Figure 63. The piston drive is of the sliding yoke type; a rotary oil pump (two vanes) delivers oil to all the moving parts and sprays it on the dome which cools the oil. Mufflers are used to minimize gas noises, and two reed valves are used in the compressor.

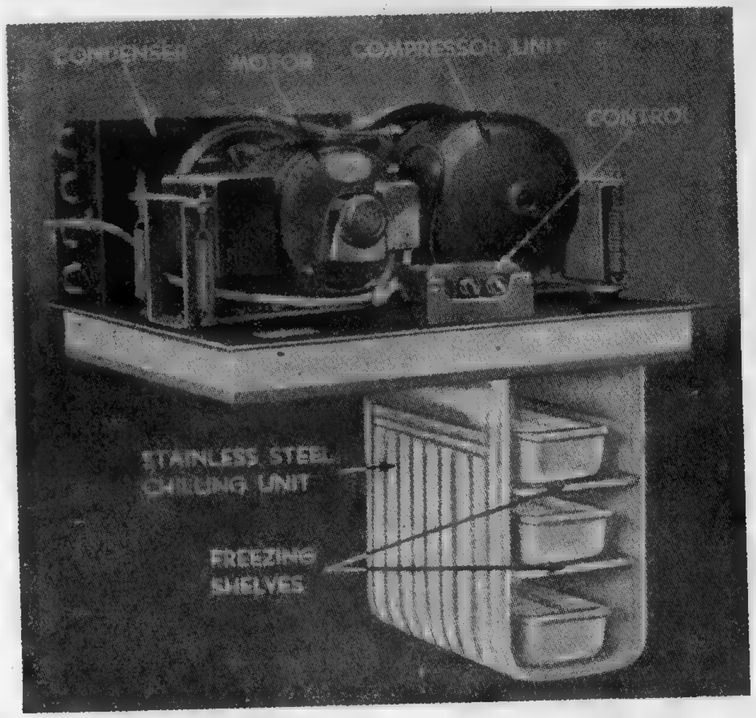


Fig. 65. The flat top General Electric rotary unit
(Courtesy of: General Electric Company)

This company also produced a flat top unit using a semi-hermetic design with a belt-driven rotary compressor. Figure 64. The assembly of the complete unit may be studied in Figure 65 and one should note the shroud on the condenser and the spring mounting of the unit. The motor used is the capacitator type and the fan is the General Electric silent type. The high side float is not shown, for it is located beside the condenser in front of the compressor. Note that the

base of the unit forms the top of the cabinet; therefore, it is insulated.

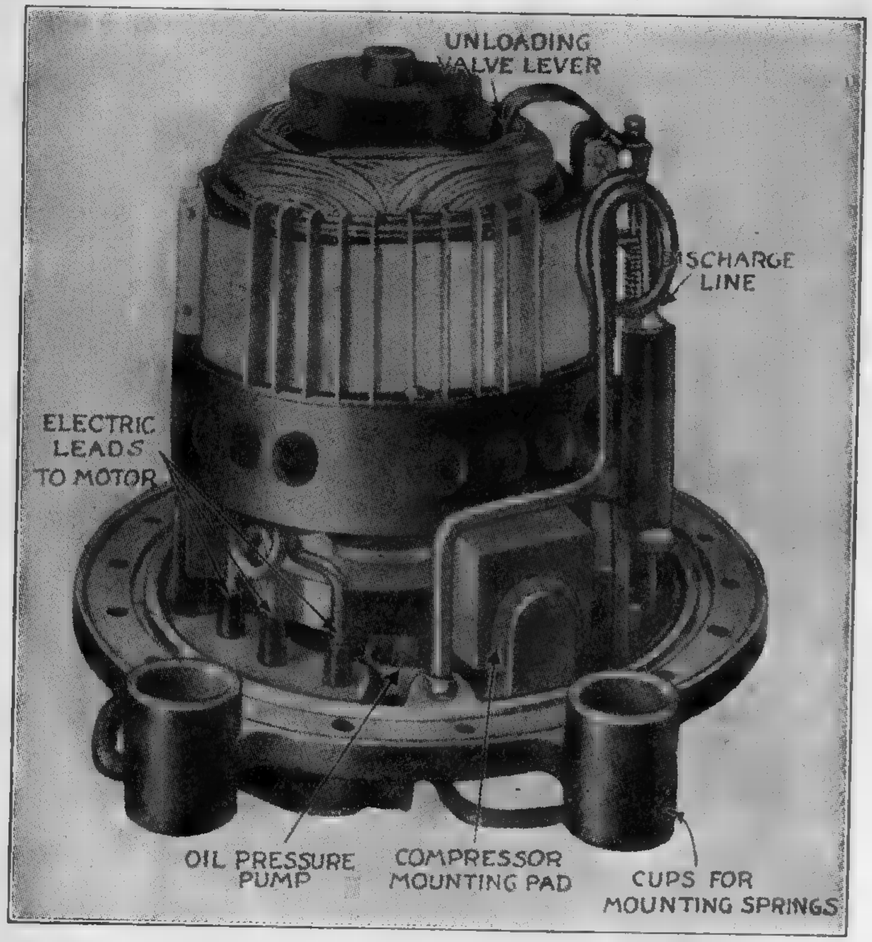


Fig. 67. The Servel Hermetic compressor showing the unloading levers and the motor
(Courtesy of: Servel Sales, Incorporated)

69. SERVEL:

The Servel Corporation of Evansville, Indiana, has a hermetic unit domestic refrigerator which differs from the other hermetic designs in that the condensing unit is located in the

base of the refrigerator rather than in the top. They are able to do this as explained by Figure 66. This unit uses what is called a derby construction, which is the typical dome seal under which is located an electric motor directly driving a horizontal reciprocating compressor. This compressor has a mechanical pressure release to relieve the starting load on the electric motor. It has an unusual feature in the liquid

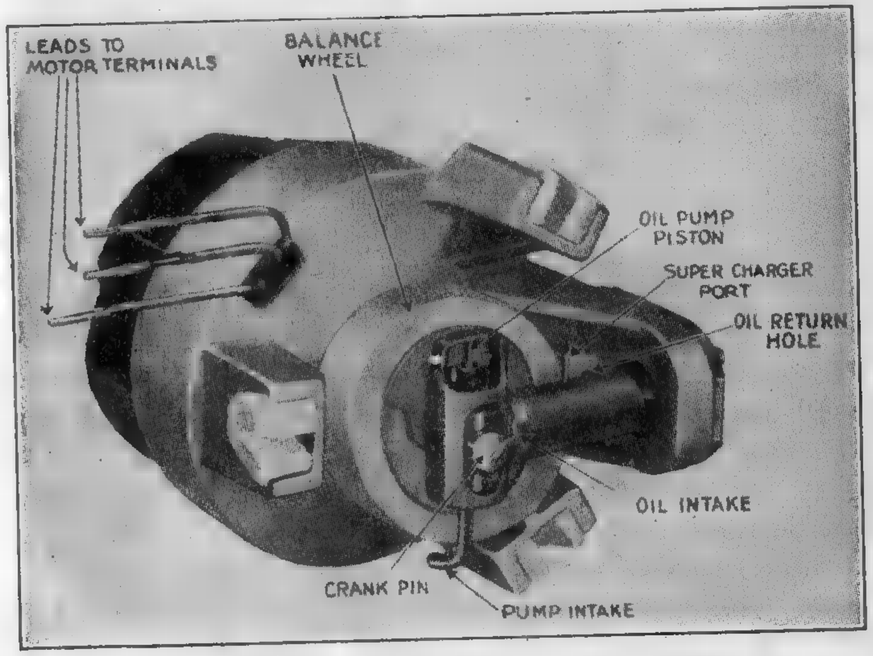


Fig. 68. The Servel Hermetic compressor
(Courtesy of: Servel Sales, Incorporated)

tube which differs from conventional construction in that it is a very small diameter high resistance capillary tube, thus permitting only a very slow flow of liquid through it, eliminating the necessity of using an expansion or float valve. The motor has a special starting winding having an external control (typical of practically all hermetic machines). Figures 67 and 68 illustrate details of the compressor.

All of the hermetically designed refrigerators use an induction motor in order to eliminate the use of contactors and other parts that might need servicing within the sealed compartment. Notice that the dome is under low pressure and that the compressor is a reversed, piston-cylinder type. The cylinder slides up and down, the piston being driven by the yoke type of drive; the exhaust valve is located in the piston. A piston type oil pump is used and is driven from the yoke. The complete assembly, including the cooling unit, may be studied from Figure 66.

70. SPARTON:

The Sparks-Withington Company, during 1932, 1933, and 1934 built a reciprocating compressor cycle refrigerator, designed with a horizontal two cylinder opposed, direct drive compressor. Figure 69. The condensing unit or machine unit is located in the upper part of the refrigerator and is connected rigidly to the cooling unit so that the whole assembly may be removed from the box as one piece. Note that the pistons are of one-piece construction driven by a common connecting rod. The crankshaft is hollow and the low pressure gas is drawn through it to provide lubrication. The intake opening is a port in the cylinder wall which is uncovered when the piston is at lower dead center. Figure 70.

For the larger cabinets, a parallel construction was used wherein two condensing units were connected to one cooling coil. This unit also has a special feature in the design of the service valves. It has two of these valves, a high side valve; the refrigerator is not equipped with the valves themselves, but only with a valve fixture to which the service man may attach the valves. (See Paragraph 202.) The cooling unit is the direct expansion type using a manually adjusted,

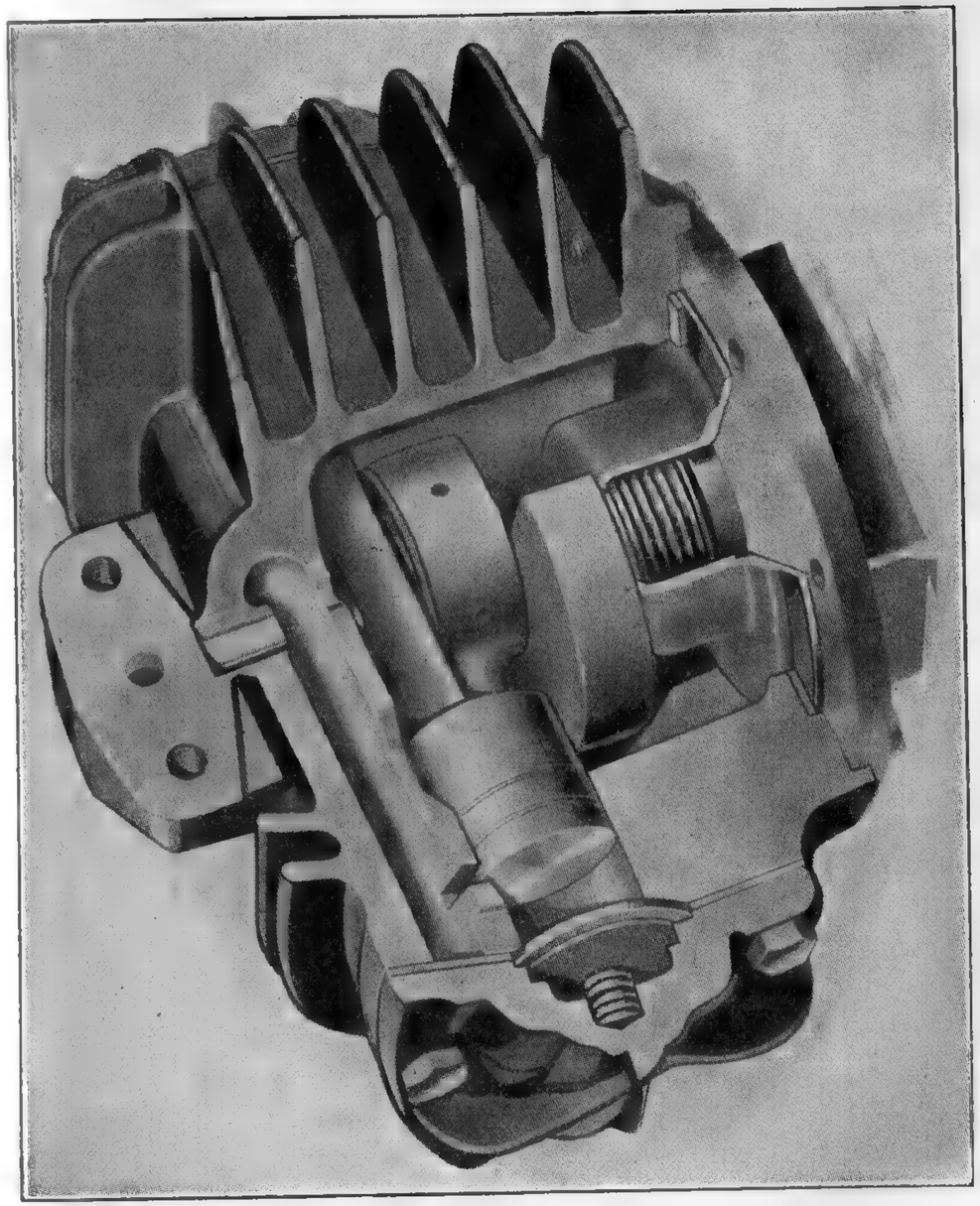


Fig. 70. The Sparton 1932, 1933, and 1934 compressor
(Courtesy of: The Sparks-Withington Company)

pressure controlled expansion valve; the refrigerant used is sulphur dioxide.

This company is now (1935) producing a conventional refrigerator with a one-cylinder, vertical, belt-driven compressor completely equipped with service valves. This unit is the first unit produced in the history of domestic refrigeration with the view to facilitate servicing by independents.

71. SUNBEAM:

The Sunbeam refrigerator mechanism distributed by the Sears and Roebuck Company (Cold Spot) uses a rotary compressor, directly driven system installed in the upper part of the cabinet. Figure 71. This refrigerator has several unique features, most important being the air-cooling of the oil; part of the condenser is equipped with oil tubes and, therefore, all the oil used in the refrigerator is cooled before being used. The compressor itself is a four-blade rotary pump with the housing placed off-center and the blades held in the rotor by means of slots. The blades are held against the outer housing by centrifugal force only, which the company claims eliminates much of the starting torque on the electric motor. Figure 18. A check valve is placed in the suction line to prevent a backing-up of the pressure into the cooling unit when the compressor is not running. Figure 99. The electric motor is connected to the compressor by means of a flexible coupling and a typical sylphon seal is used where the compressor shaft goes into the compressor.

Pressure lubrication equal to about 60 pounds per square inch is provided by the design, which enables the compressor to run in a continuous oil bath. A settling tank is used in the cooling unit to prevent any surge of refrigerant back to the compressor through the suction line.

The direct expansion cooling unit is used with an adjustable expansion valve. The condensing and cooling units may be removed from the box as one complete assembly by simply lifting it out. The servicing possibilities are limited to the adjustment of the thermostat, the adjustment of the expansion valve, the adjustment of the electric motor as to lining up, etc., and renewal or repair of the flexible coupling between the electric motor and the compressor. A horizontal, tubular receiver is used as a frame or foundation for the electric motor, compressor, and condenser on the earlier models. Servicing possibilities may be found explained in Paragraph 205. Internal flare nuts are used throughout and are soft soldered after assembly.

72. WILLIAMS' CAPITAL ICE-O-MATIC:

The Williams' Oil-O-Matic Manufacturing Company has built a refrigerator so designed that it need not use a crankshaft seal. This refrigerator is sealed under a dome and is unusual in that it has two electrical motors, one of which is sealed in to drive the compressor, which is a horizontal, single cylinder, reciprocating type. The other small electric motor is used to provide forced draft over the air-cooled condensing coils. Figure 72. The whole unit is compactly designed with the condenser located below and around the compressor; the whole unit may be placed on top of the cabinet, at one side, or underneath as seems fit. The refrigerant is methyl chloride and the apparatus is equipped with a filter or dehydrator to remove any moisture. It has an oil trap also to keep oil away from the cooling unit which is the open-pan float type. The apparatus is equipped with service valves and is completely serviceable although it is of the sealed design. Figure 73.

Note that the intake valve is a port, and that an eccentric crankshaft and connecting rod are used. A "Mercoid" switch.

centrifugally operated, is used to disconnect the starting winding. This unit may be mounted on top, at one side, or in the bottom of the cabinet.

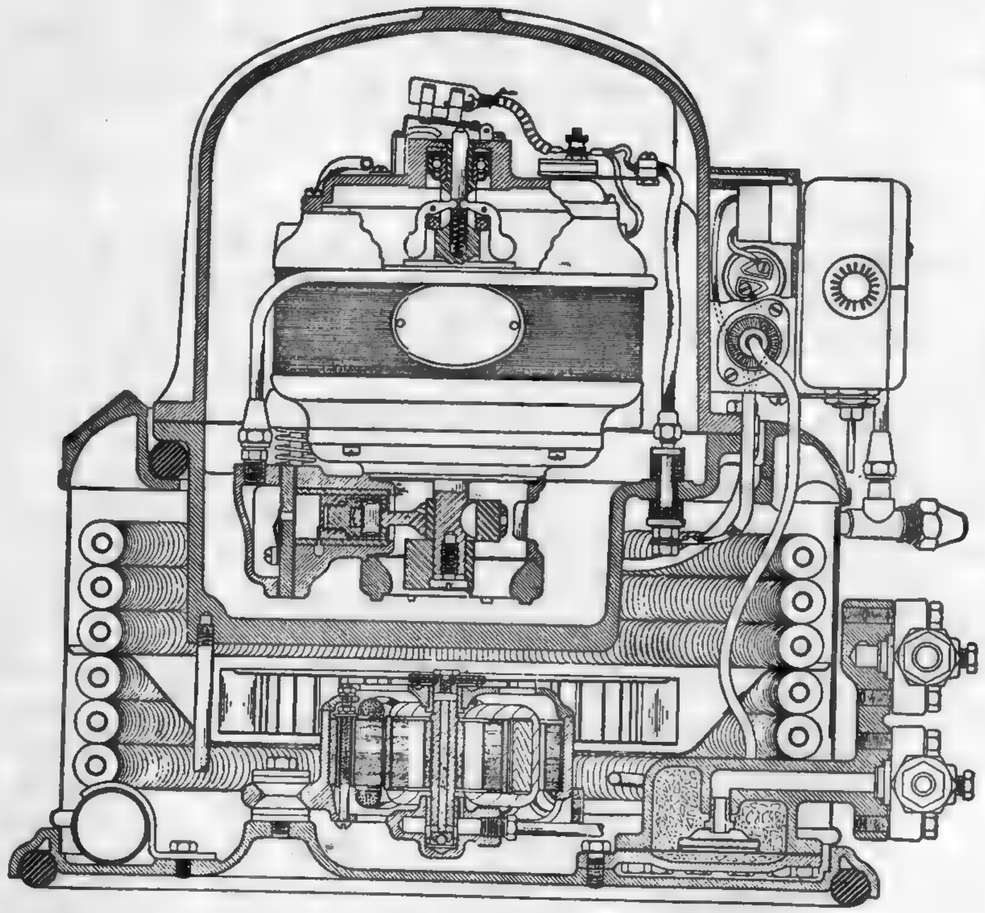


Fig. 73. The Capital Ice-O-Matic compressor
(Courtesy of: William Oil-O-Matic Heating Corporation)

73. CROSLEY ROTARY UNIT:

The latest Crosley product (1935) is a directly driven rotary compressor, enclosed in a common dome with the motor. The motor is mounted vertically and a natural convection con-

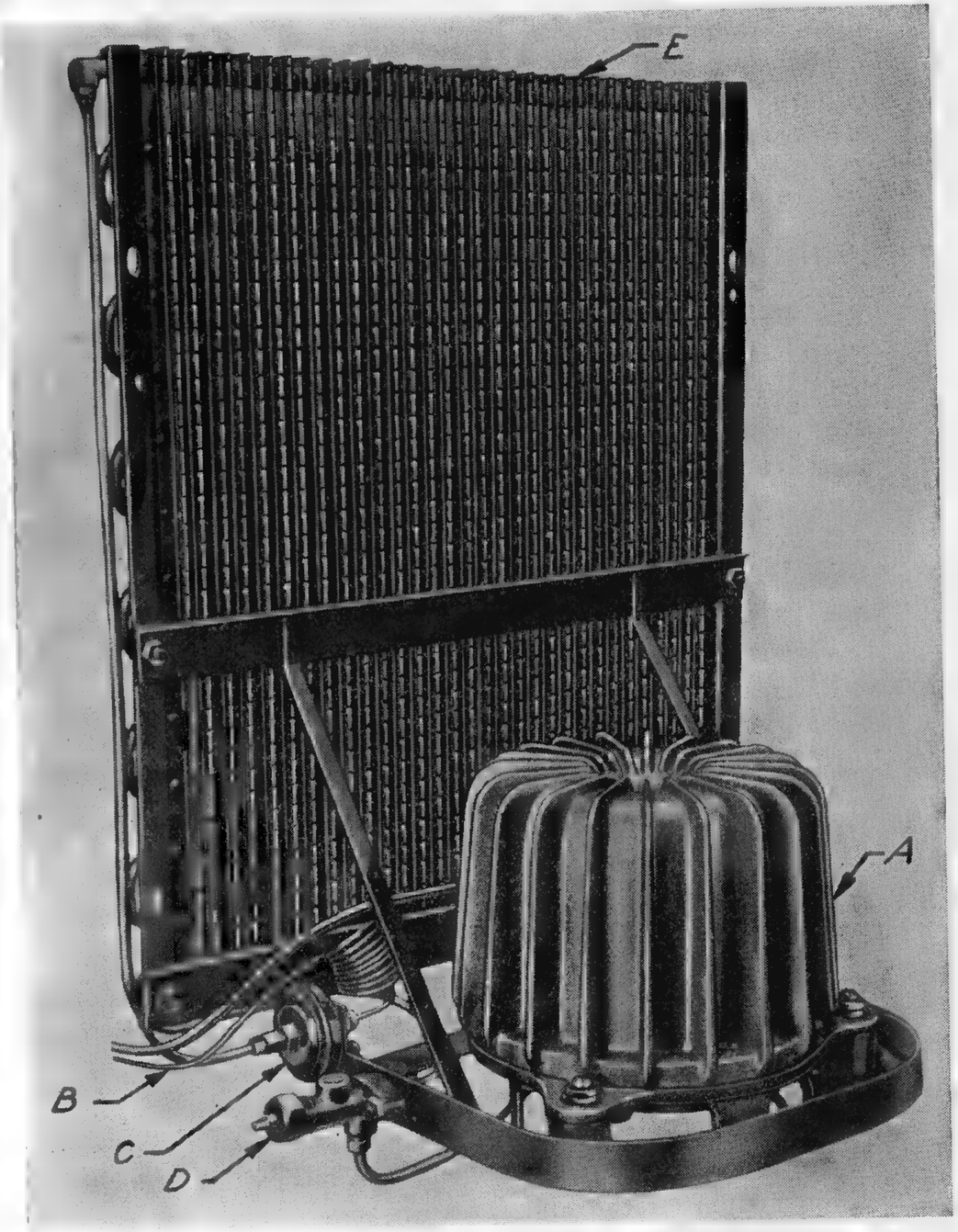


Fig. 74. The Crosley Rotary unit
A. Motor and rotary compressor unit; B. Capillary tube; C. Filter; D. Discharge service valve; E. Natural convection condenser
(Courtesy of: The Crosley Radio Corporation)

denser is located on the back of the box. Figure 74. The condensing unit is located in the base of the box. It is equipped with servicing valves, making the unit completely serviceable in the field. The refrigerant control used is a capillary tube. The refrigerant is Thermon.

74. FRIGIDAIRE STANDARD:

The Frigidaire Corporation produced a Standard line in 1934. The Standard line inaugurated a new policy with the company in that the unit was hermetically sealed. This refrigerator uses a directly driven, rotary compressor, connected to an electric motor, sealed under a steel dome. A capillary tube (restrictor) refrigerant control is used. A natural convection condenser is mounted on the back of the cabinet. This unit has been continued in 1935 with modifications. Figure 75. The unit uses F-114 as the refrigerant. The system is constructed to permit the balancing of the low and high side pressures while idle, which relieves the motor from a load when starting. The motor used is 1/20 H.P. or 1/16 H.P. depending upon the size of the cabinet. The filter trap in the suction line prevents any liquid refrigerant from entering the compressor.

75. GRUNOW:

In 1933 the Grunow refrigerator, manufactured by the Household Utilities Corporation, was offered to the public. Carrene is the refrigerant which it uses. Carrene is one of the most unusual refrigerants in that it operates under a vacuum both on the high and low pressure sides. Normally, the pressures are 27 inches of vacuum on the low side and 5 inches vacuum on the high pressure side. The unit consists of a rotary vane type compressor directly driven by the

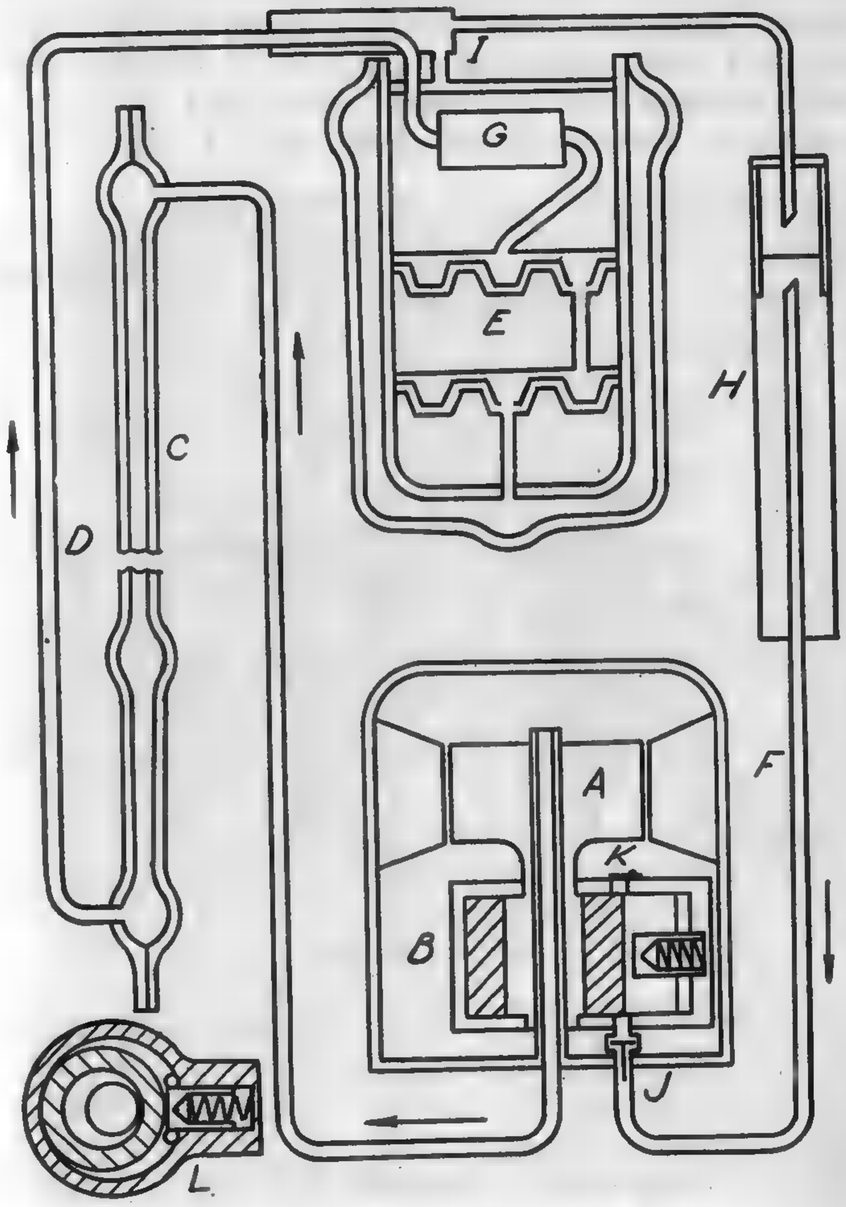


Fig. 75. Frigidaire Standard hermetic cycle
A. Motor; B. Rotary compressor; C. Natural convection condenser; D. Liquid line; E. Cooling coil; F. Suction line; G. Capillary tube (restrictor); H. Surge cylinder; I. Heat exchanger; J. Intake valve; K. Exhaust valve; L. Top view of the compressor

motor. Both the motor and the compressor are mounted vertically under a common dome in the new models, although the first model used an external motor and a double crankshaft seal. Figure 76. The 1934-35 model uses a high side

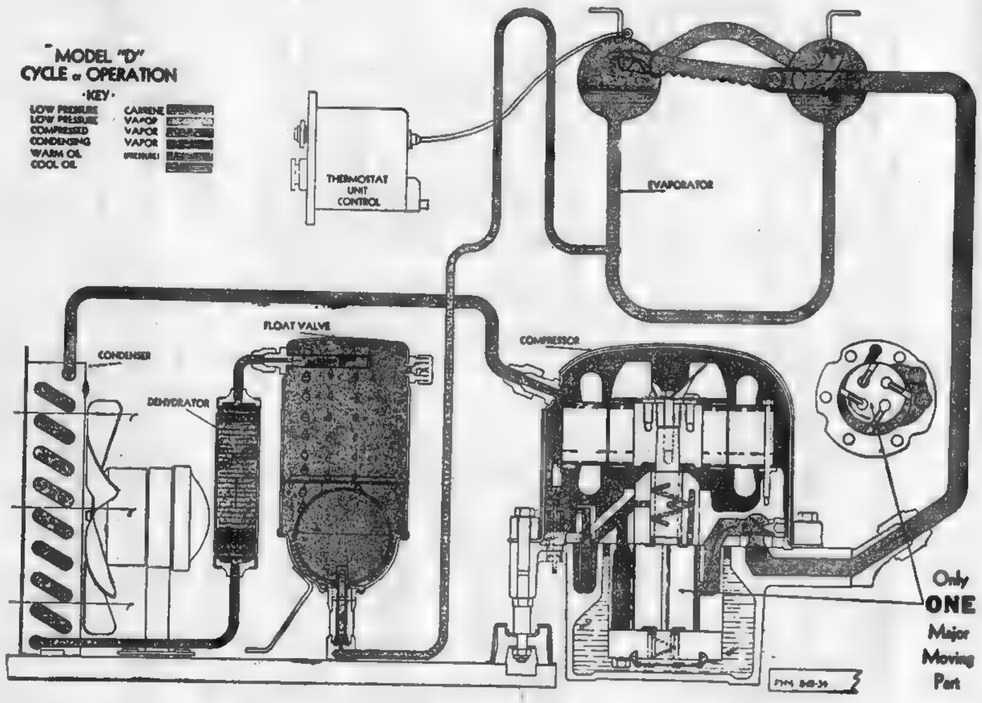


Fig. 76. The Grunow cycle diagram
(Courtesy of: Household Utilities Corporation)

float mounted beside the condenser which is cooled by a separate fan and motor. A dehydrator is permanently mounted between the high side float and the condenser The high side float is constructed in such a way that the chamber can hold all of the refrigerant in the system. A typical thermostatic motor control is used; this is mounted on the cooling coil. All of the condensing units are mounted in the base of the cabinet. Some of the cabinets use a flush door rather than the common type.

76. GIBSON:

The Gibson Electric Refrigeration Company of Greenville, Michigan, has been using a hermetic machine for four years.

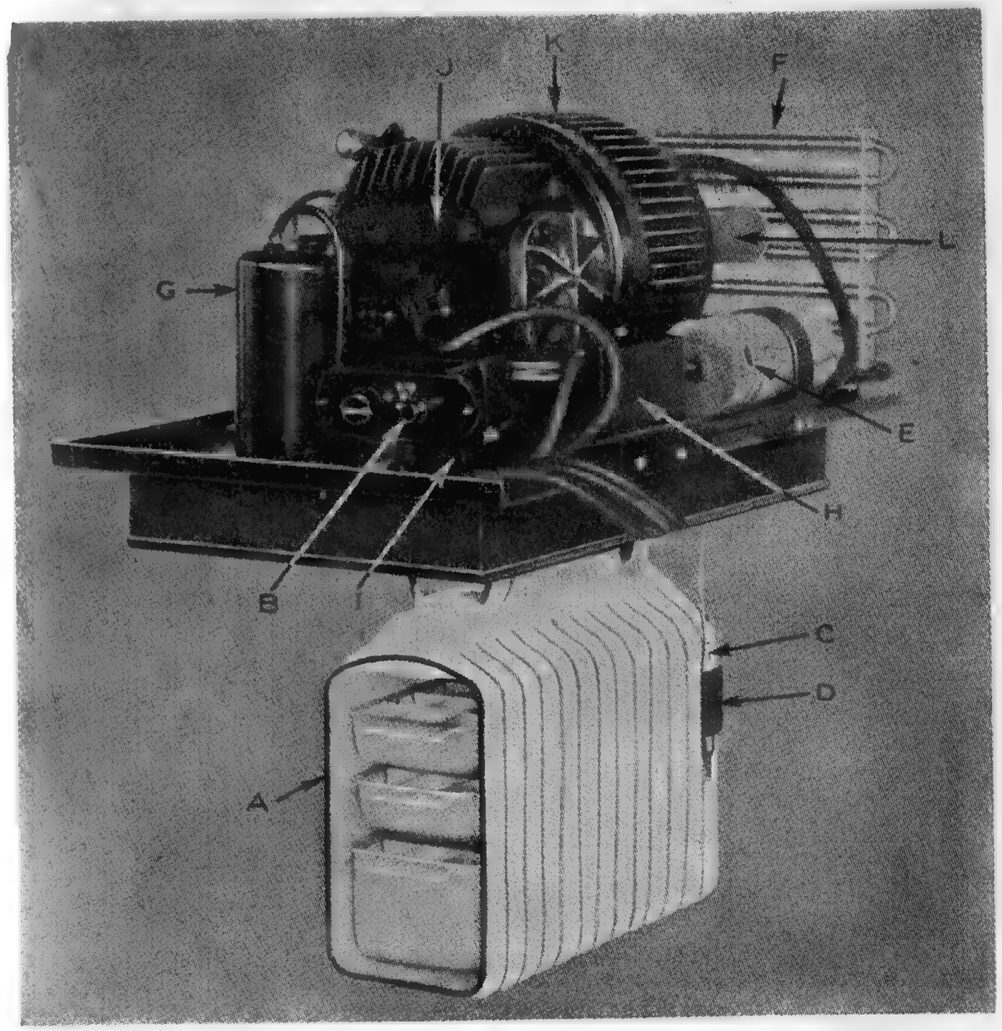


Fig. 77. The Gibson unit
A. Evaporator; B. Thermostatic control; C. Control bulb; D. Bulb clamp; E. Capacitator; F. Condenser; G. Float valve; H. Relay box; I. Terminal box; J. Compressor housing; K. Motor housing; L. Fan
(Courtesy of: Gibson Electric Refrigeration Sales Corporation)

Their first mechanisms (1930) were semi-hermetic, using a two-cylinder horizontally opposed compressor. The unit was directly driven and the cooling fan was located on the end of

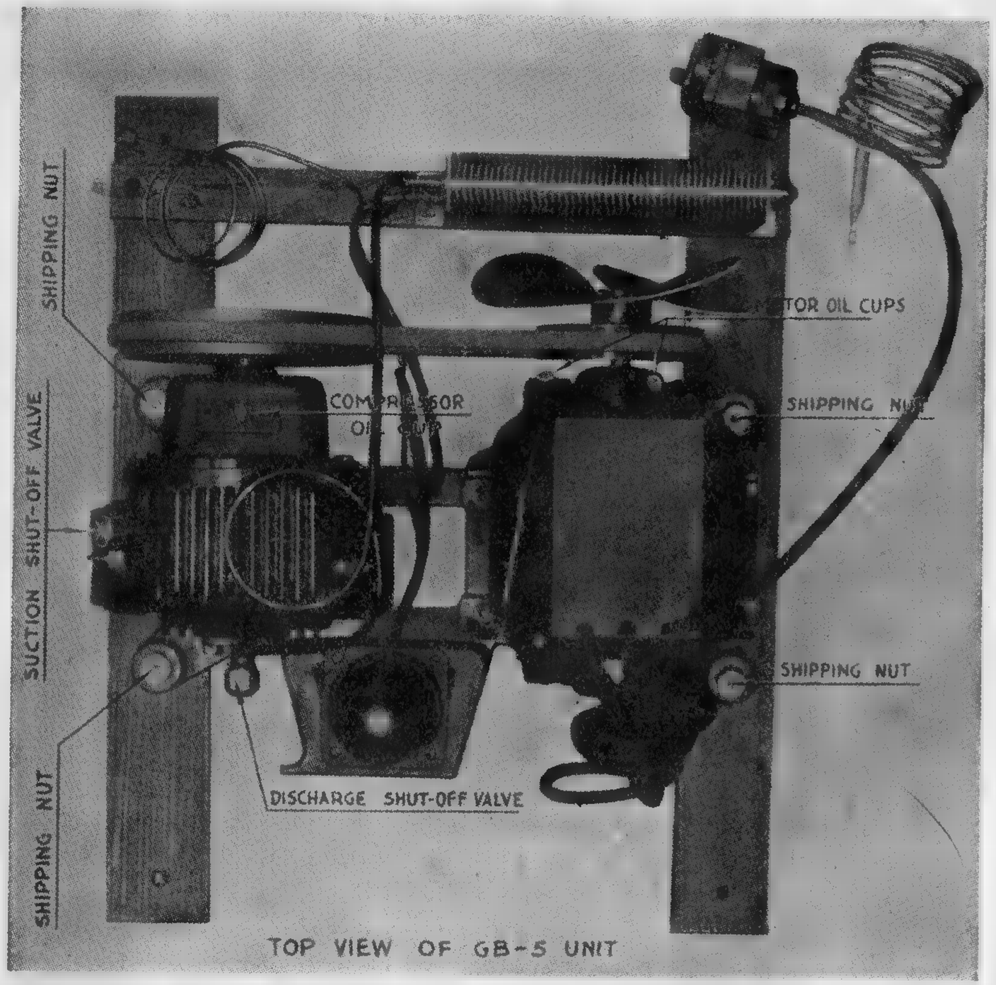


Fig. 79. The Gibson belt-driven condensing unit
(Courtesy of: Gibson Electric Refrigeration Sales Corporation)

the motor shaft. A typical crankshaft seal was used along with an expansion valve refrigerant control. The unit was equipped with a high side and a low side service valve attach-

ment and used sulphur dioxide as the refrigerant. Figure 77 illustrates the hermetic Mono-Unit which was produced in 1933 and 1934. The motor was placed inside the sealed compressor housing which eliminated the crankshaft seal. A high side float refrigerant control replaced the expansion valve used on the earlier models.

The 1935 hermetic machines also use sulphur dioxide and have a high side float refrigerant control. The valve on this control consists of a sliding button rather than the needle valve. On the 1935 models, the unit is located in the base of the refrigerator, but all previous models were of the package type having the condensing unit located in the top of the cabinet. The 1935 model has shut-off valves in the liquid and suction lines only, to permit replacing of the condensing unit. Figure 78. The cooling unit is unique in refrigeration, for it is across the top of the box. A conventional machine is also made by this company and uses the same compressor, but it is belt-driven and runs at 1000 revolutions per minute. Figure 79. The hermetic model uses a 1/5 H.P. motor and the conventional model a 1/6 H.P. motor.

77. REVIEW QUESTIONS:

Answers to the following questions may be found on page 809.

1. What is a hermetic refrigeration mechanism?
2. What advantage is claimed for the rotary compressor over the reciprocating type?
3. Name the two types of rotary compressors.
4. Why must rotary compressors be equipped with check valves?
5. What is meant by a semi-hermetic mechanism?
6. What company produces the "Monitor Top" refrigerator?

7. What refrigerant controls are used in hermetic refrigerators?
8. Why must unloading devices be incorporated in hermetic machines?
9. What is the purpose of the extra electric motor on some hermetic and semi-hermetic mechanisms?
10. May one mount gauges on the Capital Ice-O-Matic?
11. Referring to Figure 54 what pressure is the oil, in the oil reservoir of the compressor, under?
12. Why is a wick used in connection with the suction opening in the low side float control, Figure 59?
13. What is the color of the high pressure gas in Figure 66?
14. What kind of a compressor is used on the 1933 and 1934 Sparton refrigerator?
15. How is the compressor driven, Figure 71?
16. What pressure is inside the dome in the Capital Ice-O-Matic refrigerator?
17. What refrigerant is used in the 1935 Crosley rotary refrigerator?
18. What kind of refrigerant control is used on the Frigidaire Standard refrigerator?
19. What are the normal operating pressures in the Grunow refrigerator?
20. How is the 1935 Gibson cooling coil arranged in the refrigerator cabinet?

CHAPTER VI

DOMESTIC ABSORPTION REFRIGERATORS

The newest development in domestic refrigerators has been the marketing of the so-called gas-fired refrigerators. These refrigerators are of the absorption type and thereby have entirely different construction features and service operations than the compression cycle refrigerators. In Chapter III the absorption cycles of these different domestic refrigerators are explained in detail and it is the endeavor of this chapter to bring out the construction features and the servicing possibilities of these refrigerators.

78. ELECTROLUX:

The first absorption refrigerator to become popular on the market was the Electrolux made by the Electrolux Refrigerator Sales Incorporated, Evansville, Indiana. Figure 80 and Figure 81 illustrate the two Electrolux cabinets and the refrigeration mechanism installed in these two types. In both Chapters III and VII the operation and control of the Electrolux refrigerator are discussed in detail. In Chapter III the cycle is discussed thoroughly, while in Chapter VII the valves and their adjustments are carefully explained. The models of this refrigerator up to 1933 must be supplied with both gas and water, while some of the 1933 models are air-cooled. The gas is used to supply the heat energy necessary for operation, and the water is used as the cooling medium. When hooking up the refrigerator to the sources of supply of gas and water, valves both manual and automatic must be installed. In the water line there is installed a manually adjustable pressure reducing valve, a strainer, and a manual valve; in the gas line there is installed a

pressure reducing valve, a manual valve, a strainer, an automatic temperature shut-off, a temperature control, and a

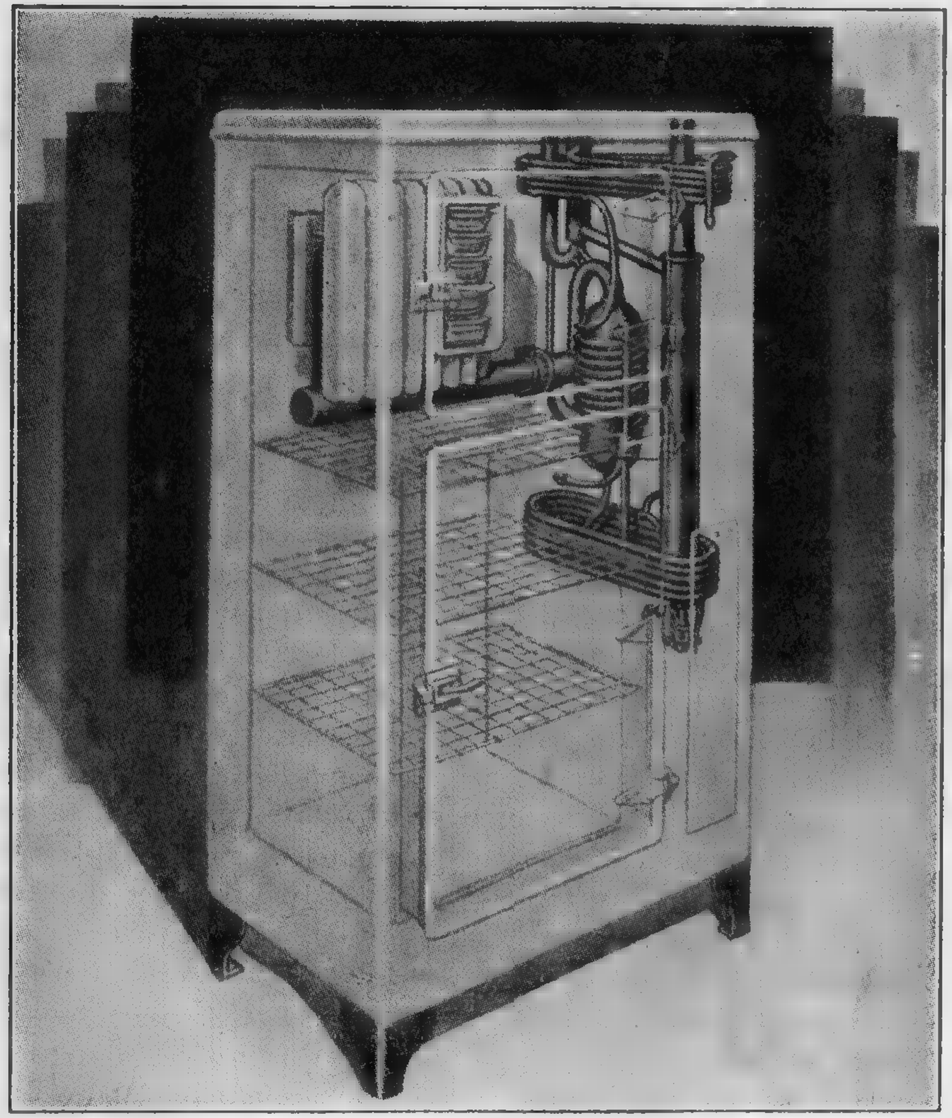


Fig. 80. An early (1927) Electrolux, water cooled, refrigerator unit and cabinet
(Courtesy of: Electrolux Refrigerator Sales, Incorporated)

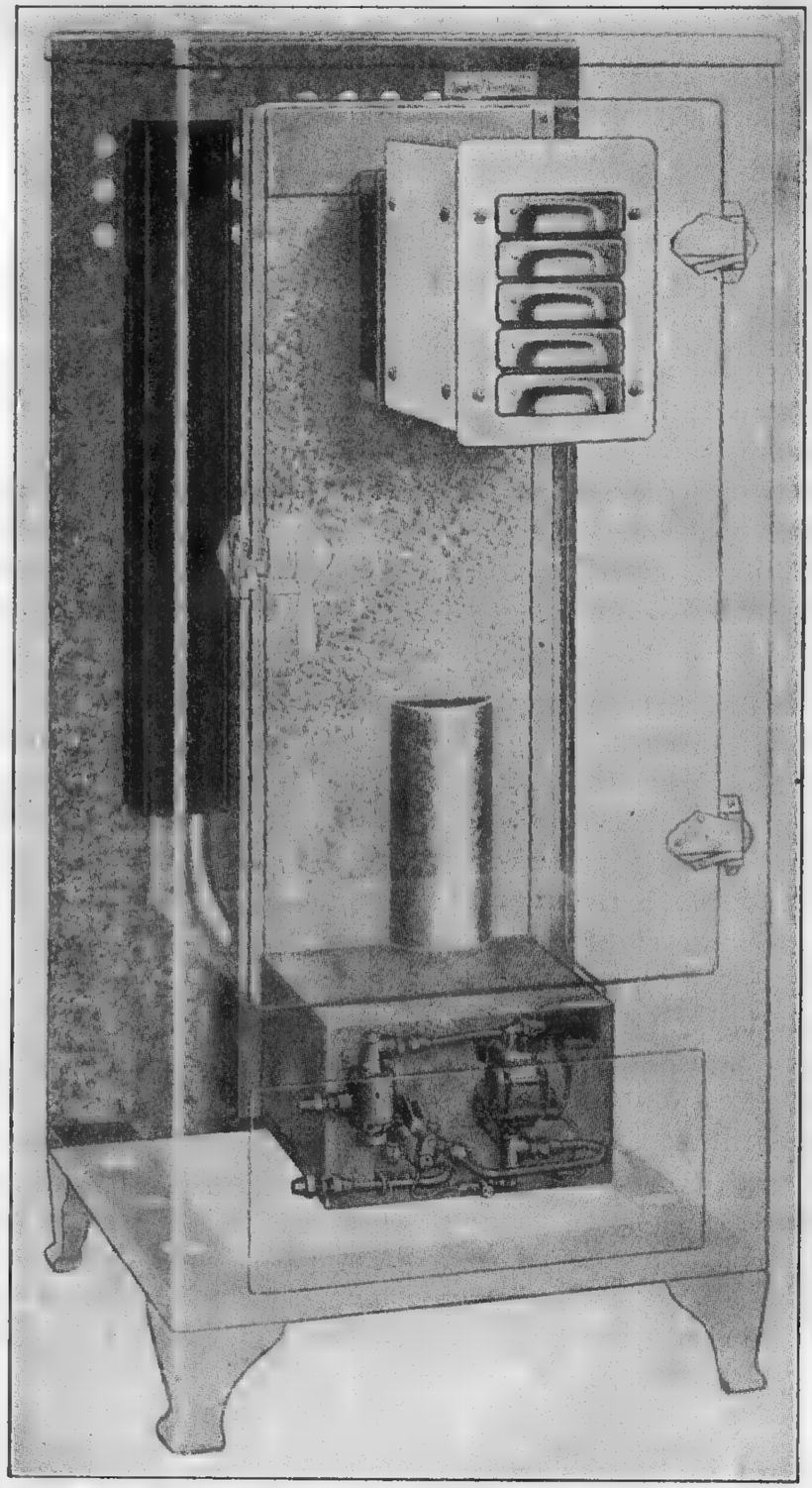


Fig. 81. The Electrolux water-cooled unit (1933)
(Courtesy of: Electrolux Refrigerator Sales, Incorporated)

safety cut-out to handle the gas supply to be burned. See Chapter VII for details of these valves.

The Electrolux, besides being offered in the domestic cabinet, is also obtainable in water coolers, market boxes, and ice cream cabinets.

79. THE AIR-COOLED ELECTROLUX:

The Electrolux Sales Corporation announced their air-cooled unit in 1933 and are continuing the model with cabinet refinements in 1935. The new Electrolux air-cooled unit is charged with a small quantity of aqua ammonia (distilled water and ammonia) and hydrogen. Figure 82. The charge distributes itself naturally in the unit; the liquid seeks the lowest levels and the hydrogen and ammonia gas fill the remaining space.

With the application of heat at the generator (1), ammonia vapor is driven from the strong solution (aqua ammonia) and, together with small quantities of the strong solution, is raised through the pump tube (2) to the weak liquid stand pipe (3). Ammonia vapor with traces of water vapor, is driven off in the stand pipe (3), leaving the aqua ammonia solution comparatively weak in ammonia (weak solution). The hot ammonia vapor then passes from the stand pipe (3) through the submerged analyzer (4) and the high temperature rectifier (5) where the small amount of water vapor entrained is condensed and drains to the submerged analyzer (4). When the hot ammonia vapor reaches the upper condenser (6), part of it is liquefied by cooling. These condensers are finned, and natural convection produces a steady flow of air over them. The liquid ammonia maintains a level in the condenser (6), causing the liquid ammonia to flow into the box cooling coil (7a). If the heat load on

the refrigerator is above normal, all of the ammonia vapor will not be liquefied in the top coils of the condenser (6), the vapor passes to the lower coils of the ammonia condenser (6), and the resultant liquid flows to the freezing coil (7b). In both of these cooling coils the ammonia evaporates and absorbs heat.

In a cold room, the greater part of the ammonia vapor is liquefied in the upper ammonia condenser (6), and flows into the box cooling coil (7a), from where it drains to the freezing coil (7b).

Any ammonia which does not condense in the upper part of (6) condenses in the lower tubes, and when enough collects in the U-tube, the liquid ammonia passes into the freezing coil (7b). This arangement tends to maintain a more nearly uniform box temperature with varying room temperatures, without the necessity of changing the temperature control.

An atmosphere of hydrogen gas, continually sweeping the surface of liquid ammonia in the cooling coil, keeps removing the ammonia vapor and causes continued evaporation. The ammonia vapor thus formed in the cooling coils mixes with hydrogen gas, and the mixture is made to flow upward through the evaporator. This permits the location of the box cooling coil (7a) in its most effective position, namely, at the top, at the same time the hydrogen gas, which is saturated with ammonia passing upward from the freezing coil (7b) is enabled to pick up more ammonia at the higher temperature prevailing in the box cooling coil (7a). Still another advantage results from the pre-cooling of the liquid ammonia coming from the ammonia condenser—upper part (6) before it enters the freezing coil (7b). These features greatly increase the capacity of the unit.

In case not all of the ammonia vapor is condensed in the

lower ammonia condenser (6), because of a high room temperature, the vapor passes through the equalizer (13) to the pressure chamber (14), which contains a quantity of reserve hydrogen. This results in the displacement and transfer of the reserve hydrogen into the absorber (9) thereby increasing the pressure in the system to the point where all ammonia is liquefied in the lower ammonia condenser (6) and upper ammonia condenser (6). When the room temperature becomes lower, the reserve hydrogen returns to the pressure chamber (14). This automatic pressure change permits very efficient operation of the unit under normal room temperature conditions; therefore, it is not necessary to charge the unit initially with a high pressure to enable satisfactory operation under extreme conditions.

In the gas heat exchanger (8), cool heavy gas from the evaporator comes in thermal contact with warm light gas from the absorber (9), effecting a heat exchange and increasing the unit efficiency. The long column of heavy gas, rich in ammonia (ammonia and hydrogen mixture) in the center of the gas heat exchanger (8), readily overbalances the short column of heavy gas in the cooling coil, thereby causing the desired upward flow in the cooling coil. A flow of weak solution, being returned from the generator (1) through the liquid heat exchanger (10), contacts the ammonia and hydrogen gas mixture entering the absorber (9), and the ammonia is dissolved. The hydrogen being light returns to the cooling coil. The heat, which is liberated by absorption of ammonia in the absorber (9) is carried away by the vaporization of a small quantity of methyl chloride in the absorber coil (11). This vapor liquefies in the methyl chloride condenser (12) thereby dissipating the heat. The liquefied methyl chloride returns by gravity to the absorber coil (11) and is ready to be used again.

From the absorber (9) the strong solution is returned by gravity to the generator (1), passing through the liquid heat exchanger (10), where a heat transfer is accomplished because of the difference in temperature of the weak and the strong solutions. After passing, it then returns to the generator (1)

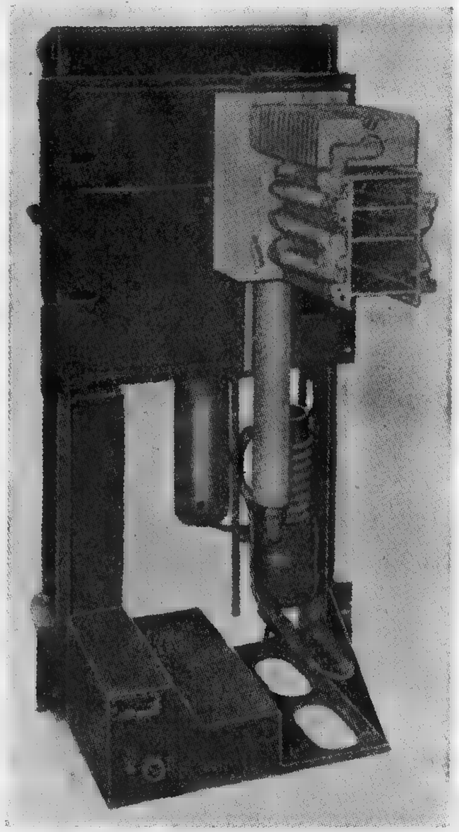


Fig. 88. The assembled air-cooled Electrolux unit
(Courtesy of: Electrolux Refrigerator Sales, Inc.)

through the bottom of the submerged analyzer (4), where part of the heat in the vapors, leaving the generator (1), is recovered by serving the useful purpose of driving some ammonia from the strong solution. This results in a further increase

in efficiency. Continued refrigeration is merely a repetition of this cycle. Figure 83.

The refrigeration mechanism that contains the ammonia is made of hand welded steel as the water-cooled unit was. However, the methyl chloride portion is made of copper and has copper fins. The fins on the ammonia condensers also are made of copper, although the tubing is steel. The gas controls are almost identical with those used in the water-cooled unit (Chapter VII).

80. FARADAY:

The Faraday Absorption Refrigerator, built by the Faraday Refrigerator Corporation, Dayton, Ohio, is of the solid absorbent type. By referring to Figure 84, it will be noted the generator or absorber assembly is built as a complete unit which is located either in the bottom of the refrigerator cabinet, or can be installed remotely, as installation conditions may require.

The evaporator or cooling unit is of the plate type, and so arranged that each ice tray comes directly in contact with a section of the cooling unit containing liquid refrigerant.

The Faraday refrigerator requires a water and gas supply and employs suitable, adjustable valves to cut down and maintain constant pressure in both these supply lines. As explained before, the Faraday cycle is intermittent; therefore the main gas burner operates only a portion of the time. This necessitates a constant pilot burner and suitable control devices to open and close the gas supply to the main burner at the proper time.

81. GENERATING PERIOD:

As in the original Faraday experiment the gas burner drives the ammonia over to the other portion of the system, but the

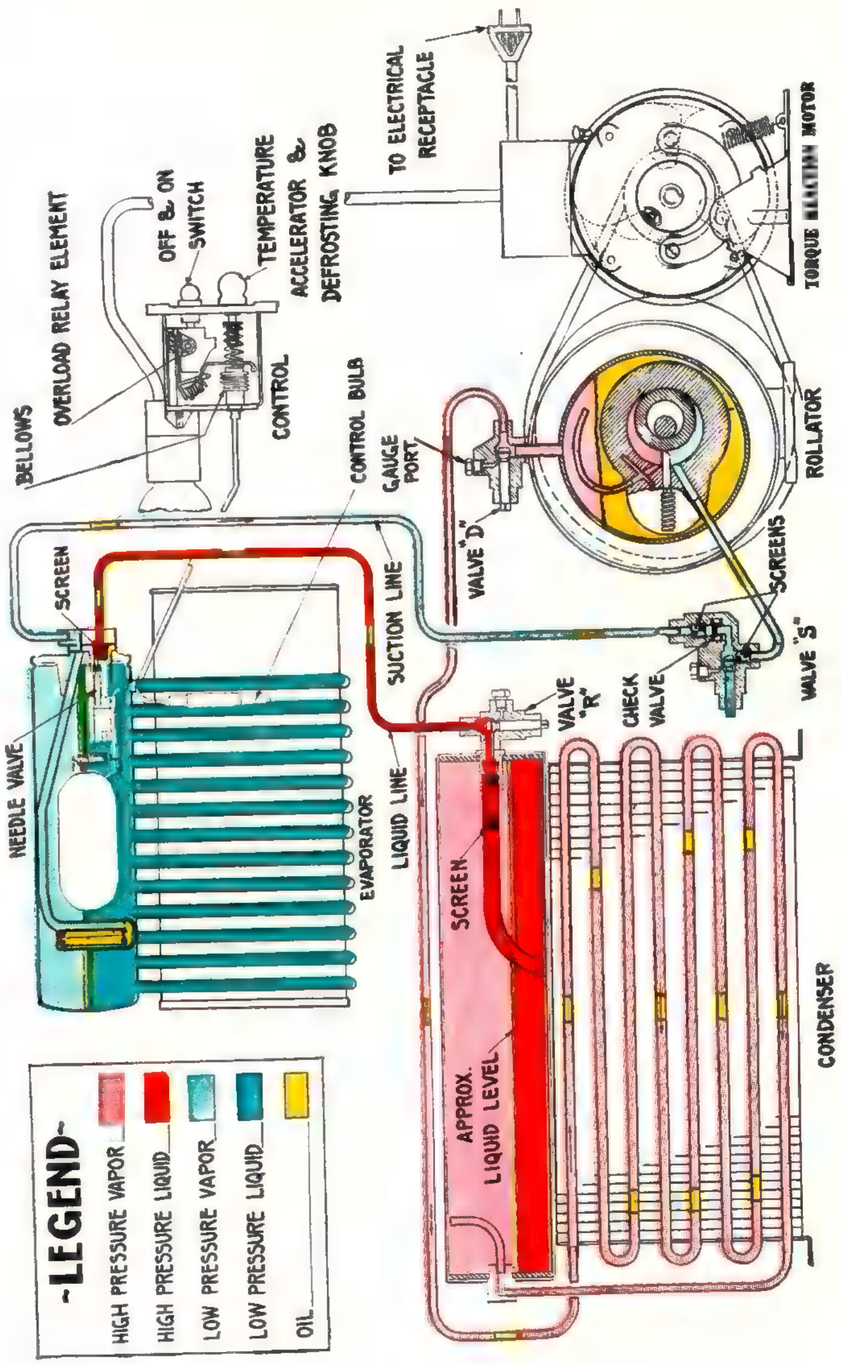


Fig. 59. The Norge 1933-34-35 cycle diagram
(Courtesy of: Norge Corporation)

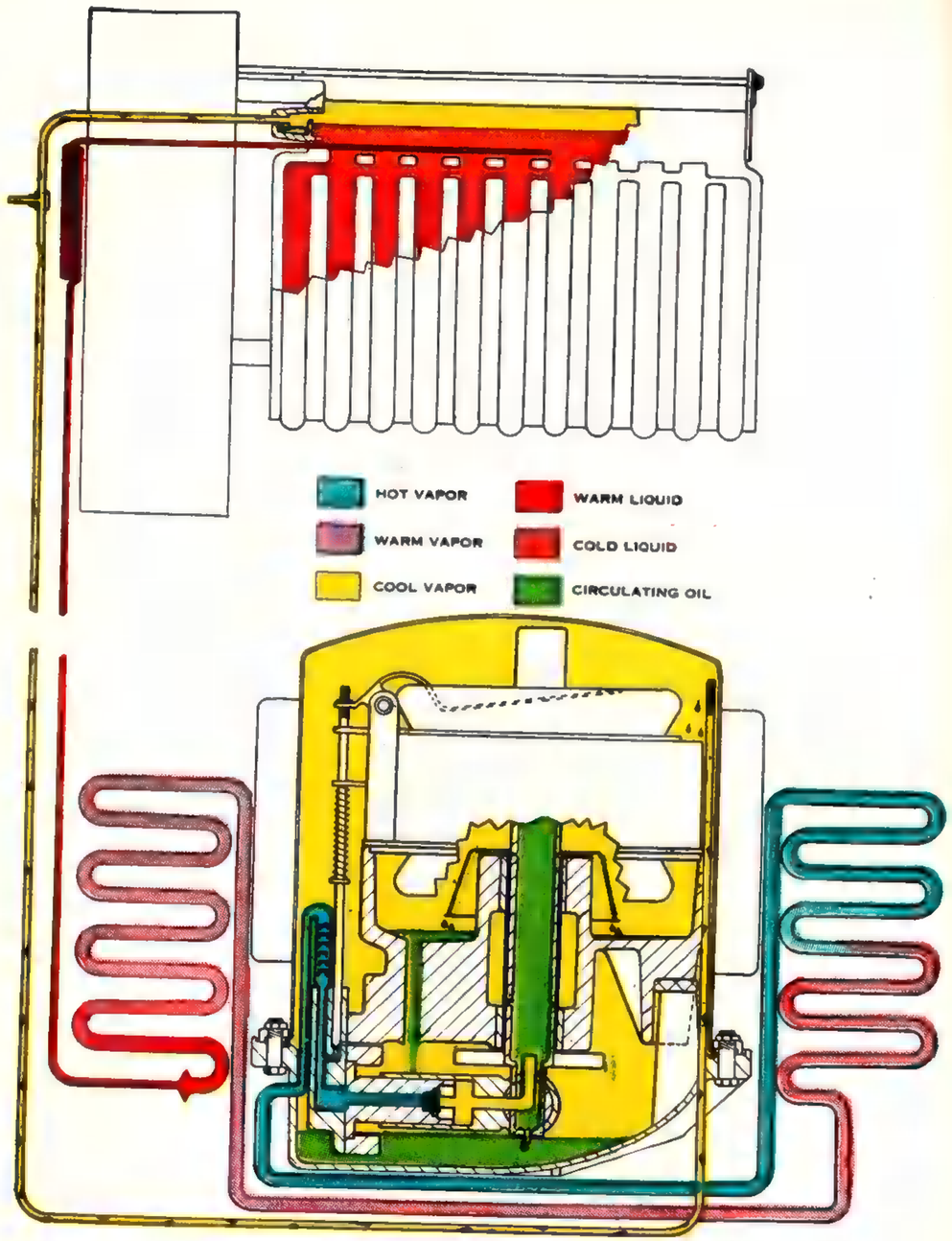


Fig. 66. The Servel hermetic cycle
(Courtesy of: Servel Sales, Inc.)

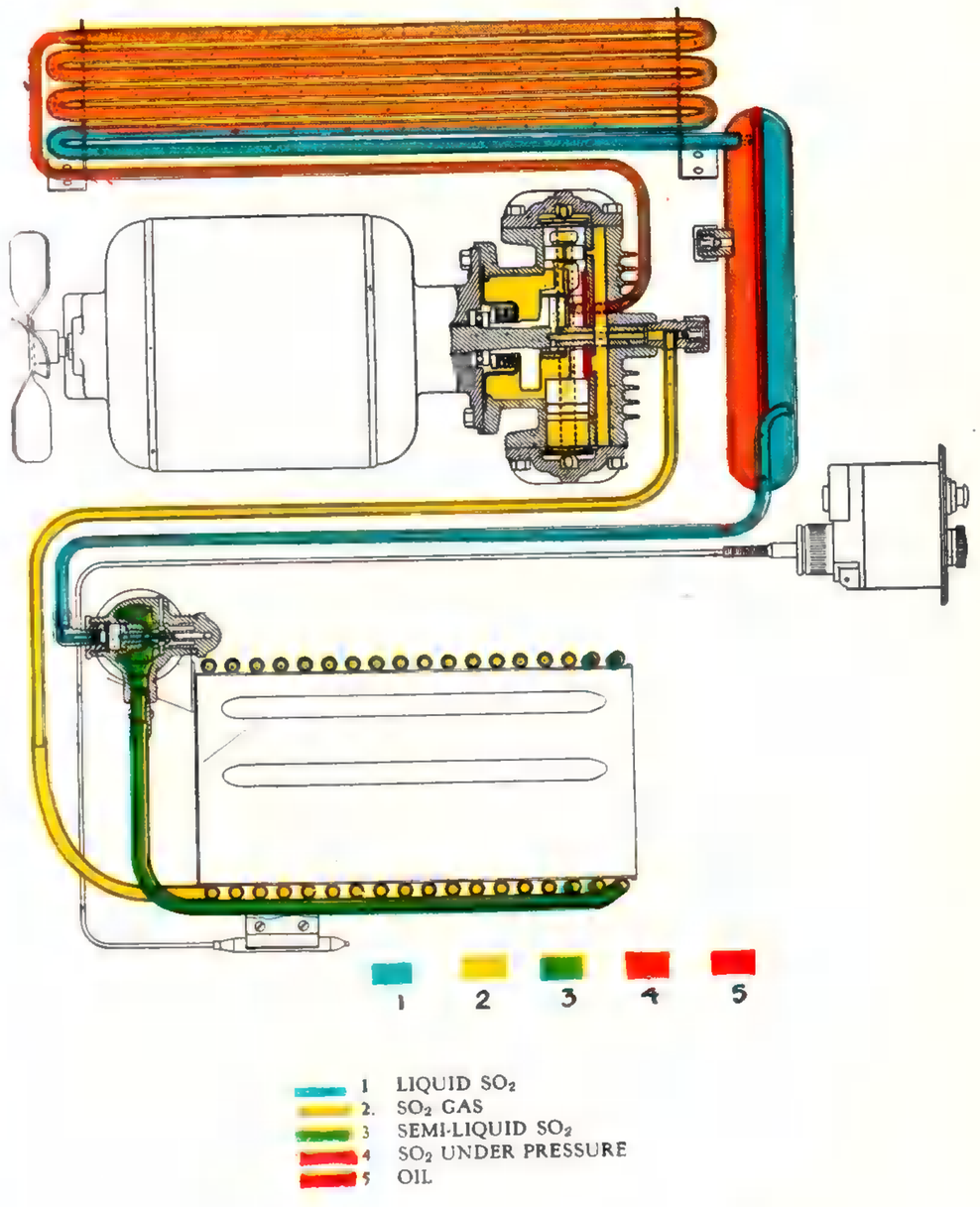


Fig. 69. The Sparton refrigeration cycle 1932, 1933, and 1934
(Courtesy of: The Sparks-Withington Company)

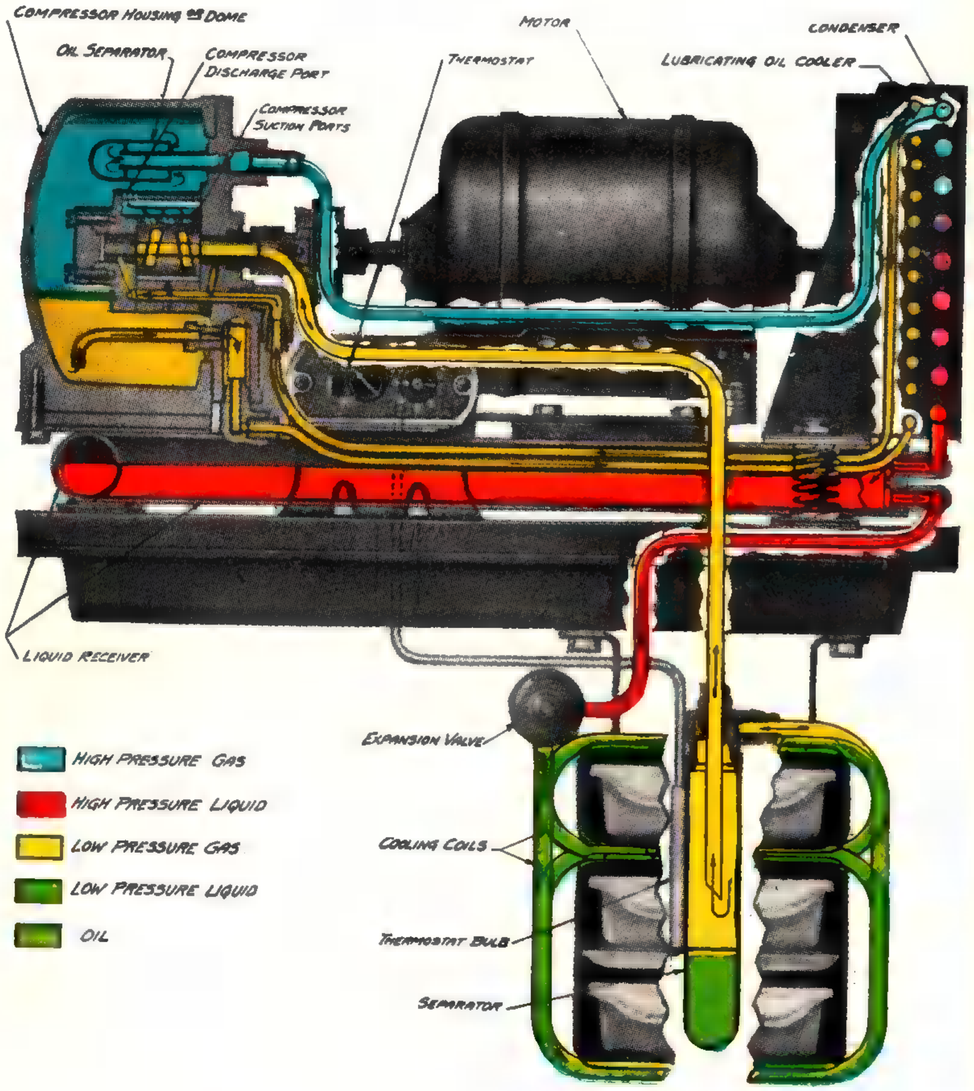


Fig. 71. The Sunbeam refrigeration cycle
(Courtesy of: Sunbeam Electric Manufacturing Company)

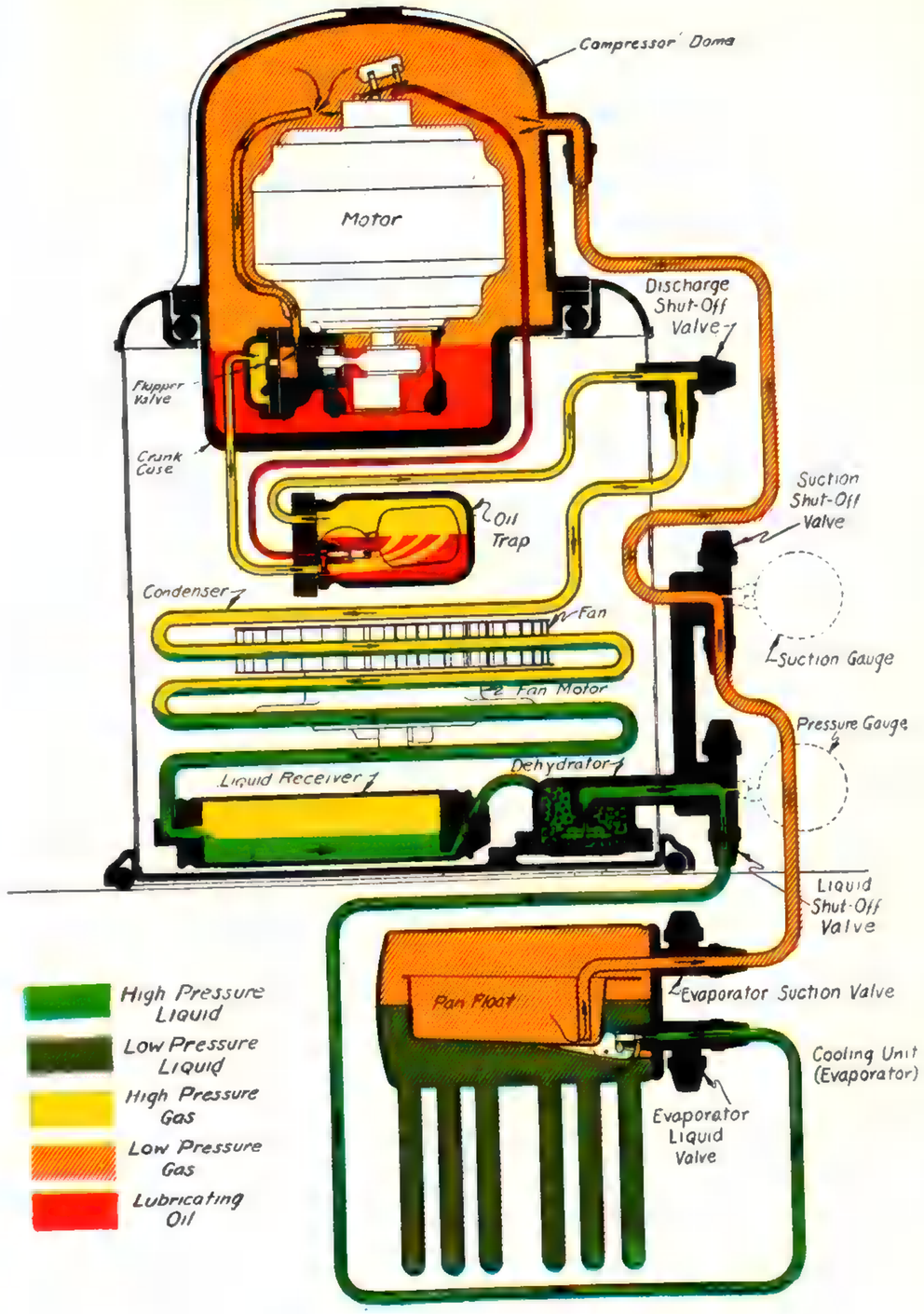


Fig. 72. The Capital Ice-O-Matic cycle
(Courtesy of: Williams Oil-O-Matic Heating Corporation)

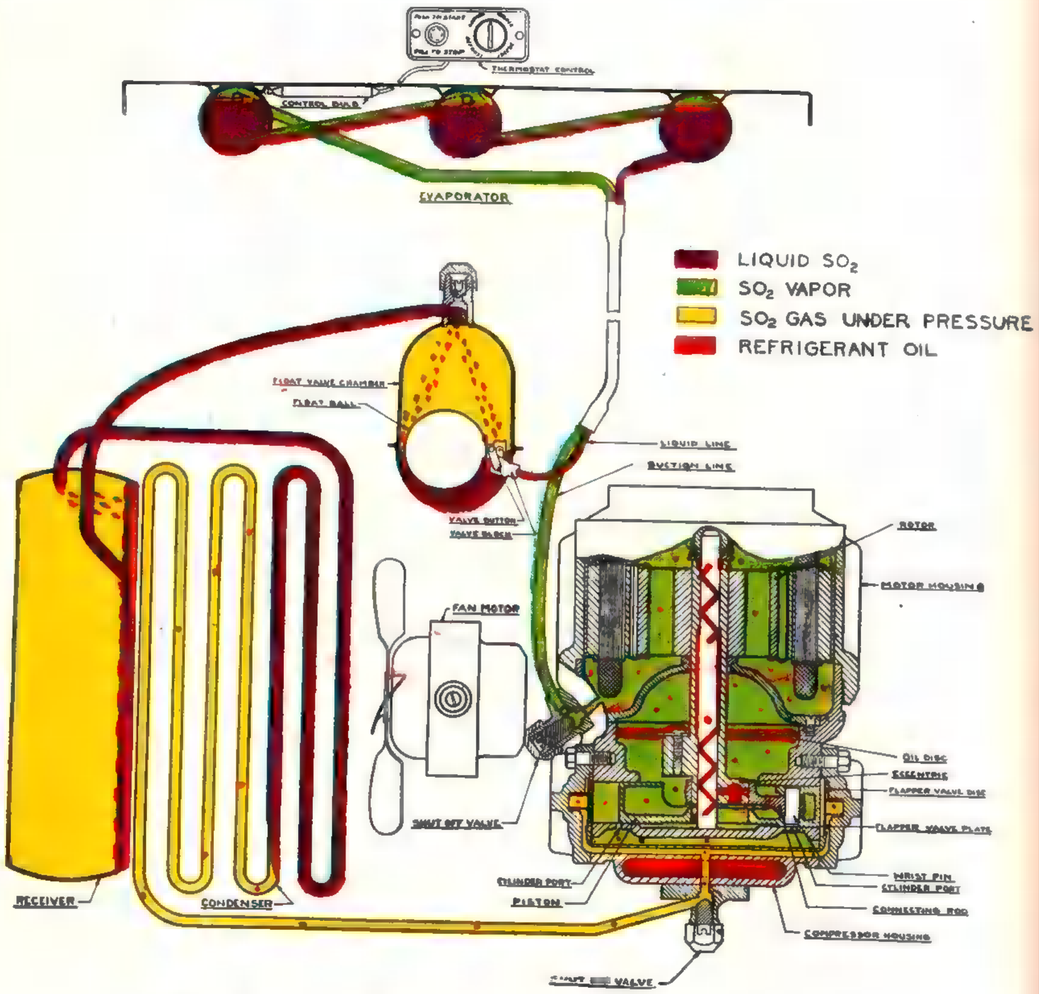


Fig. 78. The 1935 Gibson shelf and condensing unit
(Courtesy of: Gibson Electric Refrigeration Sales Corporation)

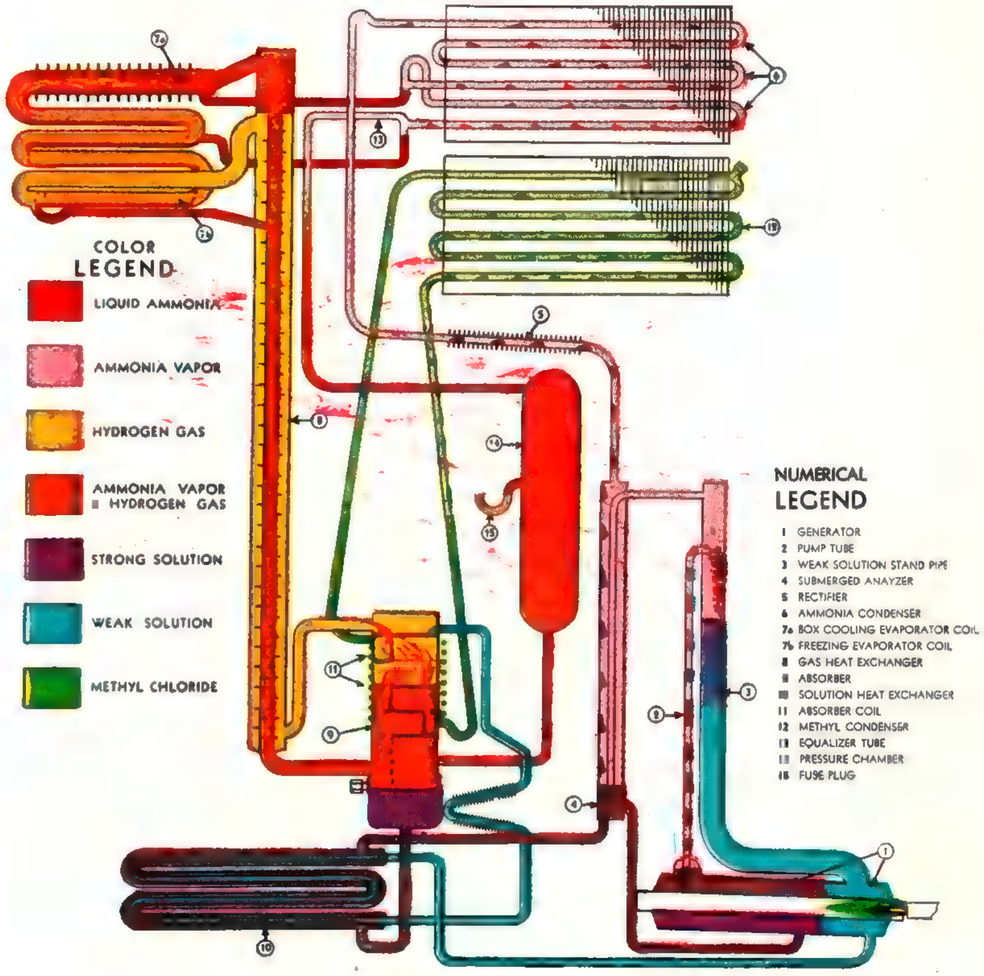


Fig. 82. The Electrolux air-cooled cycle, 1934-35
(Courtesy of: Electrolux Refrigerator Sales, Inc.)

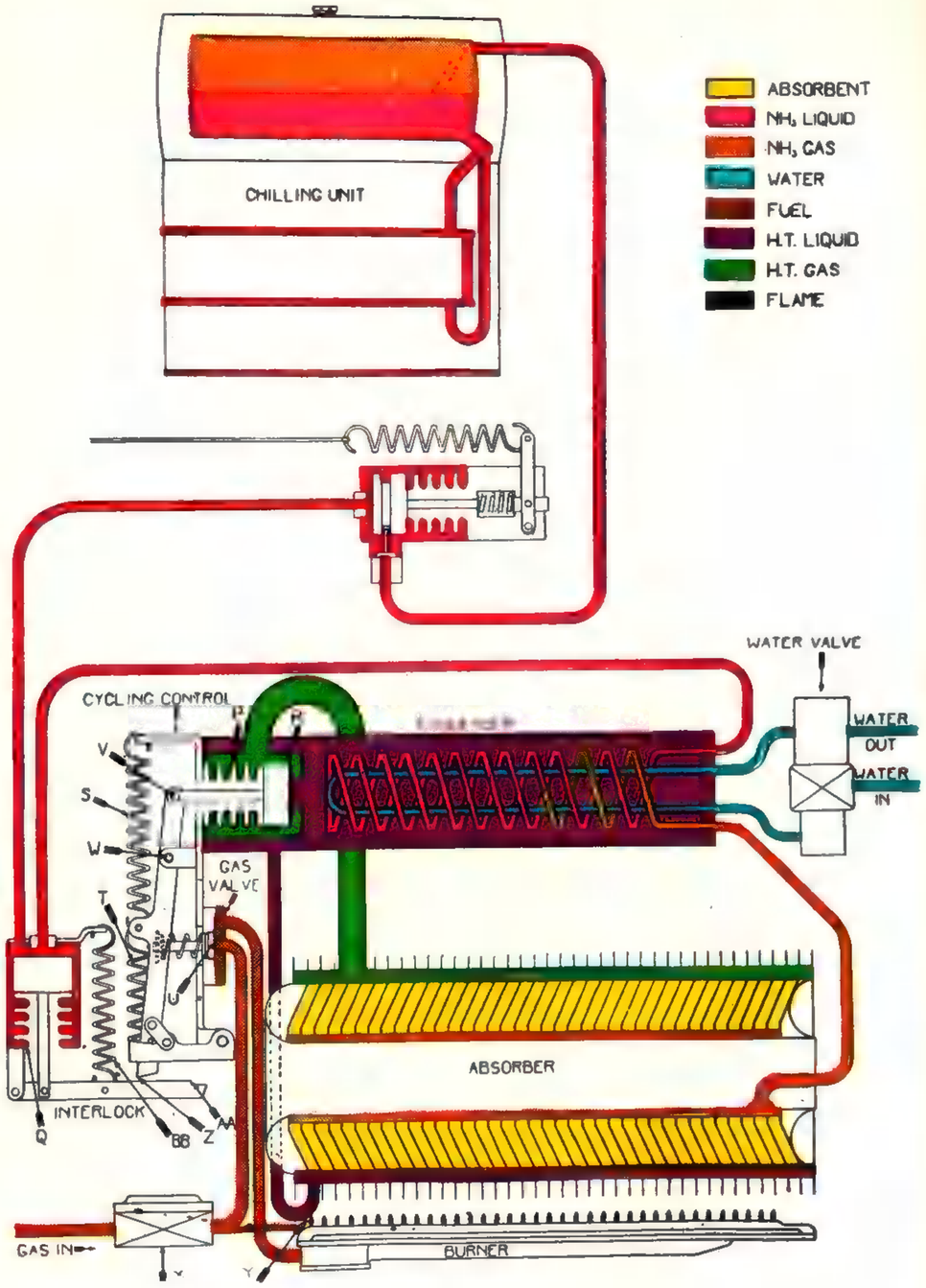


Fig. 85. The Faraday cycle

P. Vapor bellows; Q. Ammonia bellows; R. Vapor valve; S. Cycling spring; T. Differential spring; U. Gas valve; V. Lever system; W. Pivot point; X. Gas regulator; Y. Pilot light; Z. Lever; AA. Notch; BB. Spring

(Courtesy of: Faraday Refrigerator Corporation)

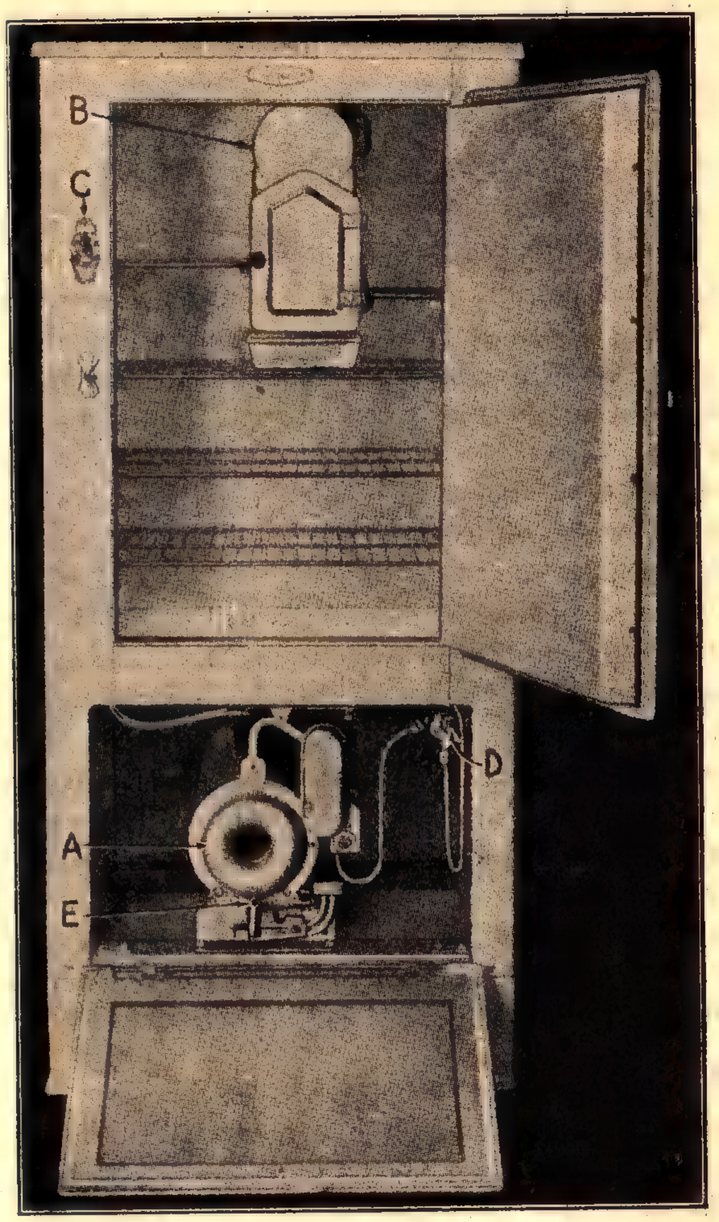


Fig. 84. The Faraday Model F-7 unit

A. Generator; B. Cooling unit; C. Temperature control; D. Temperature control valve; E. Pilot light

(Courtesy of: Faraday Refrigerator Corporation)

method of transferring the refrigerant is more involved than in the original set up.

First of all, in order to give a uniform heat application to the ammonia in the absorber generator, a steam bath of a low boiling temperature liquid, called F-11, is used. See Figure 85.

From the illustration it may be seen that as this vapor becomes heated, its pressure rises; as the valve (PR) in this vapor circuit is closed, the vapor is locked in the chamber constructed around the ammonia absorbent.

As this vapor heats, the heat is transferred to the absorbent powder, releasing the ammonia in gaseous form, which passes up into the water-cooled condenser. From here the ammonia passes on through the liquid line to the cooling unit, where it is stored.

However, because ammonia gas will condense at the coolest point of its circuit, a provision must be made so that the condensation will take place in the condensing unit rather than in the cooling unit, which is naturally very cold, being inside the refrigerator box. All that is necessary is a pressure-controlled needle valve in the ammonia line which will prevent the ammonia from seeping into the cooling unit until its pressure has reached that point where it is condensable at the temperature of the cooling water. When this pressure is reached the valve will open and allow the condensed ammonia to collect in the cooling unit.

82. ABSORBING PERIOD:

After all of the ammonia has been driven into the cooling unit, some method must be employed whereby the gas burner may be shut off. The method used is very simple.

When all of the ammonia has been driven from the absorber there is nothing to remove the heat applied to the absorber and naturally the vapor surrounding the absorber becomes

very hot and develops a higher pressure. This pressure operates upon the F-11 vapor valve (PR) and when it has become high enough forces it open, shutting off the gas supply (U) and allowing the F-11 vapor to recirculate.

The opening of this valve naturally causes a great drop in the F-11 pressure and due to its original spring pressure it tends to close. This, however, is prevented by a trip arrangement and lock (ZAA).

It will be noticed from the main diagram that the absorber heating medium, the F-11 is so circulated that it comes in contact with the condensing water; when the vapor valve is opened and this heat transfer gas allowed to recirculate, the absorber becomes surrounded immediately with a cold fluid. This causes a very rapid drop in the temperature of the ammonia absorbent in the absorber, which naturally puts this absorbent in a position to reabsorb the ammonia driven away from it. This it does as rapidly as it possibly can, and if it were allowed to do it uncontrolled, a very low temperature would be achieved in the refrigerator box.

However, this is prevented by the temperature control unit and storing unit as illustrated. This unit operates as follows: It has a valve bellows and a spring tension manually adjusted which will allow the evaporated ammonia gas in the cooling unit to go back to the absorber and be reabsorbed only after the said gases have reached a certain pressure corresponding to the freezing temperature desired in the cooling unit.

When this pressure has been reached, it overcomes the spring tension on the bellows; the valve opens and then closes again after the pressure has dropped.

Because this valve is manually adjustable, a temperature ranging from about 0°F. to 20°F. is obtainable in the cooling unit. This continues until the generator has reabsorbed all of the ammonia it possibly can after which the pressure

in this absorber will approach the pressure of the cooling unit.

Now when this condition is reached it is desired that the gas valve be reopened. This is accomplished by installing a pressure bellows valve (Q) in the ammonia line, which is attached to the trip arrangement on a combination gas and F-11 vapor pressure valve.

This is designed so that, as pressure rises in the line located between the temperature control valve and the absorber, the bellows contracts and trips the gas valve arm, which is already under spring pressure; it reopens simultaneously with the closing of the vapor valve which is attached to the same arm. This brings us back to the repetition of the cycle just explained.

From the above explanation it will be seen that there are three liquids used in the system—ammonia as the refrigerant, F-11 (trichloromonofluoromethane) which is the heat transfer fluid or bath surrounding the absorber, and water which is used to condense both of the above liquids.

The system uses about three pounds of ammonia and two pounds of F-11. These are, of course, sealed in the system.

The temperature control valve and the gas trip valve are also designed as service valves. The one (temperature control valve) is used to seal the cooling unit and the pressure trip valve seals the absorber generator unit.

Whenever a remote installation is made, the chief precaution to take is in connection with the installation of the tubing connecting the above two valves. This tubing must be dehydrated, that is, freed from water. It must also be very clean. After hooking up this tubing to the two valves, it should be sealed tightly to the temperature control valve and only loosely to the gas trip valve. The temperature control valve should then be opened a very little and the added tubing

purged, that is, cleared of air by the ammonia leaking out; then the connection of the gas trip valve should be sealed.

If by any chance the gas pilot light were to be extinguished, by becoming clogged or smothered, a thermostatic control is attached to a gas valve in the circuit and the cooling of this thermostatic valve or trip will shut off the supply of gas.

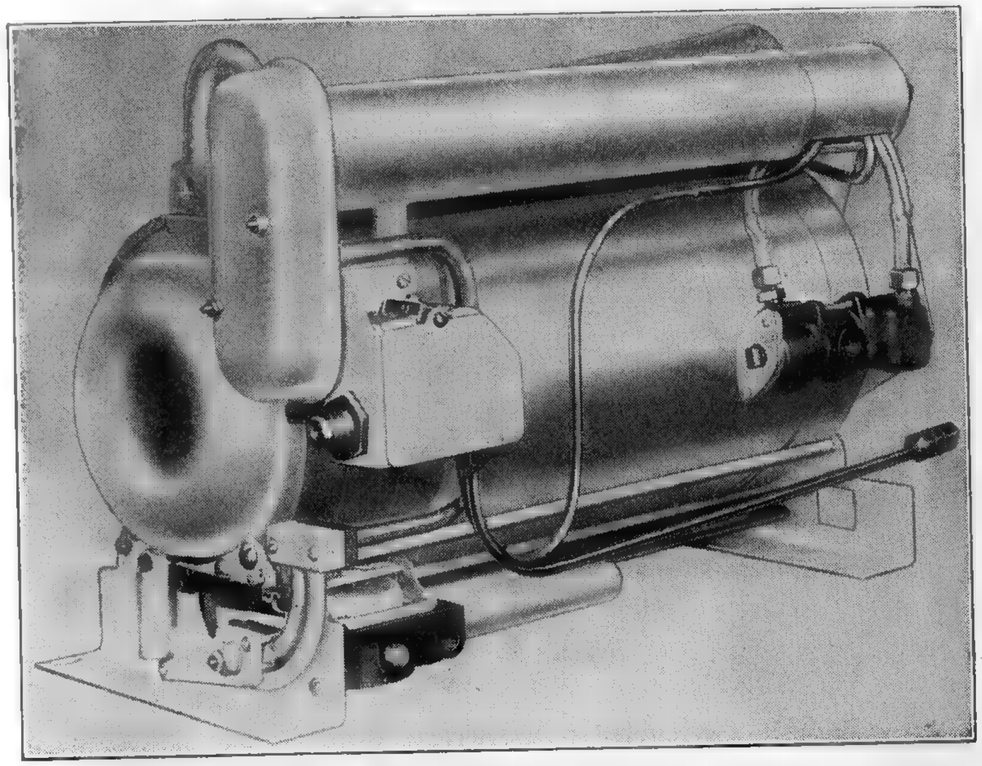


Fig. 86. Faraday absorber
(Courtesy of: Faraday Refrigerator Corporation)

The water supply is practically continuous, because part of the time it is used to cool the ammonia vapor and the remainder of the time to cool the heat transfer fluid. However, the amount of water flowing is so controlled by actual require-

ment that the minimum amount is used at practically all times. See Figures 86 and 118.

The water valve is mounted on the side of the absorber assembly at the rear so that connections may be conveniently made. The inlet water enters the opening A and passes from the valve chamber to the condenser past the water valve. The water then flows through the condenser chamber, returning to the opposite end of the water valve.

At this end of the water valve assembly there is located a sealed bulb around which the warm water passes on its way to the drain. Inside this bulb is located a metal bellows, one end of which is connected to the water valve.

Surrounding this bellows is a liquid which expands and contracts with the temperature of the outlet water. This expansion and contraction of liquid causes the metal bellows to move, operating the water valve. Therefore any changes of temperature of the discharged water will change the adjustment of the valve, that is, if the discharged water gets too hot, the water supply valve will be opened farther or if it gets too cold, the valve will be closed more. See Paragraph 107.

The gas supply is controlled by a leather valve and the gas, before passing through this valve into the burner, is passed through a filter.

A further safety feature is introduced in a safety device operating on the thermostatic strip controlling the gas valve. This device is so arranged that if the absorber assembly reaches too high a temperature, either from the failure of water supply or any other unusual condition, the device will trip the gas valve and shut off the gas supply.

83. SUPERFEX:

The Superfex refrigerator is designed, as may be seen in Figure 87 so that no explanations of its design or features

Fig. 87. Superfex cabinet
(Courtesy of: Perfection Stove Company, Incorporated)

are necessary. The manufacturers (the Perfection Stove Company, Cleveland, Ohio) claim that they have designed a fool-proof mechanism, and the only service they have been called on to give has been when a refrigerator has been in a burned building or destroyed in shipment.

Their cycle is explained in Chapter III and, outside of the cabinet care prescribed in Chapter IX, there are only two other precautions to be observed. The water-cooled condenser

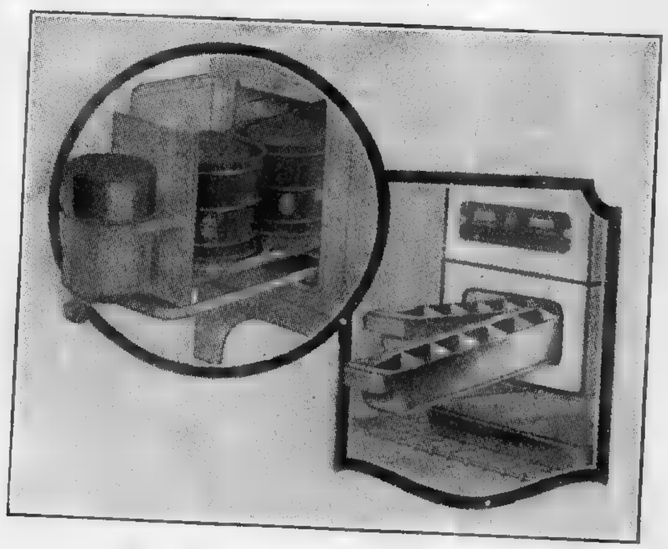


Fig. 88. Superfex burners and ice trays

is immersed in a non-flowing water tank located in the top of the box. This water level must always be kept up to the indicated level, especially just before lighting. The kerosene burners must be clean, dry, and in good condition. They must be filled to the correct indicated level and must be in a level position when burning or an improper flame will result. Figure 88. No obstructions should be placed in the heating flue as this will restrict the efficiency of the cycle.

84. TRUKOLD. MONTGOMERY WARD & CO.:

Another kerosene-fired absorption refrigerator is produced by the Gibson Electric Refrigerator Corporation and distributed by the Montgomery Ward & Co. Figure 89. This refrigerator is intermittent in operation; it uses ammonia

Fig. 89. The Trukold cabinet
(Courtesy of: Montgomery Ward & Company)

and water as the refrigerant and absorbent respectively. The kerosene stove is located under the box and the heating flue is behind the box. Figure 90.

Note the location of the liquid ammonia receiver inside the insulation of the cabinet behind and above the cooling coil.

This location is to prevent the receiver from acting as the cooling coil. The burners are mounted on racks to make shifting of them very simple. The water reservoir must be kept filled to the correct depth at all times.

85. ICY-BALL:

An ingenious refrigerator, called the Icy-Ball, is made by the Crosley Radio Corporation. It is an insulated box with a

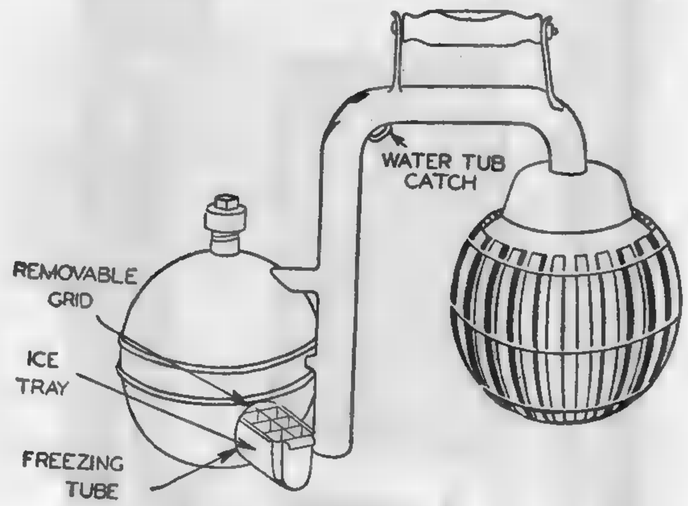


Fig. 91. The Icy-Ball unit
(Courtesy of: The Crosley Radio Corporation)

top door (chest model), and a portable generator and a cooling unit. Figure 91. It is the absorption type and operates as follows: each refrigerator is provided with a kerosene stove and a water bucket. To start operating, place the generator over the lighted stove and the cooling unit in the bucket filled with cold water for about 90 minutes. Then place the cooling unit in the refrigerator box and the generator out in the open air; refrigeration will be obtained for about 24 to 36 hours. An insert in the cooling unit is provided with an

ice-tray to make ice cubes. The unit weighs 39 pounds and is very inexpensive to operate.

86. REVIEW QUESTIONS:

Answers to the following questions may be found on Page 810.

1. What three substances are used inside an Electrolux mechanism?

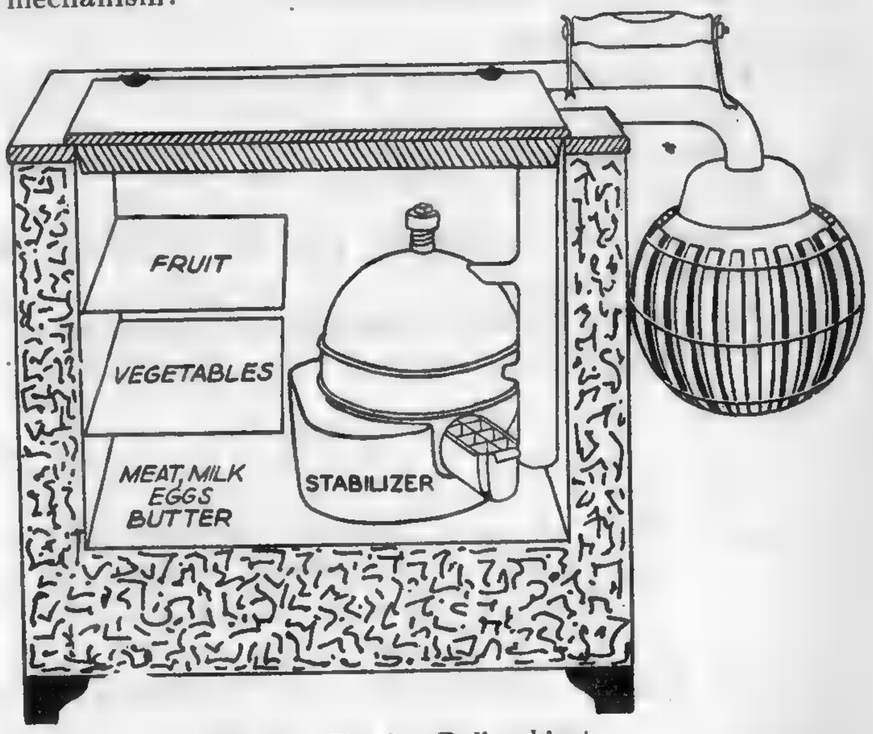


Fig. 92. The Icy-Ball cabinet

2. What is the purpose of the F-11 in the Faraday?
3. Why must a pilot light be used in the Faraday?
4. Why may copper tubing be used in the Faraday?
5. How is the Faraday water valve manipulated?
6. What does the water cool during the freezing portion of the Faraday cycle?

7. What two purposes does the temperature control valve serve in the Faraday?
8. What is the purpose of (11) in Figure 82?
9. What is the methyl chloride used for in the air-cooled Electrolux?
10. What precautions must be taken with the kerosene in the intermittent units?
11. How is the cabinet temperature adjusted in the Electrolux refrigerator?
12. Why are two cooling coils used on the air-cooled Electrolux refrigerator?
13. Why is the liquid receiver in the Trukold placed above the cooling coil?
14. What is the refrigerant used in the Crosley Icy-Ball refrigerator?
15. What is the purpose of the tank on the top of the Superfex refrigerator?

CHAPTER VII

DOMESTIC AUTOMATIC CONTROLS

It is only natural that the compression cycle and the absorption cycle have different types of controls. This is due to the fundamentally different operations of these cycles. The mechanical refrigerators have two main types of controls:

1. Refrigerant controls
   (*a*) Low pressure side float
   (*b*) High pressure side float
   (*c*) Automatic expansion valve
   (*d*) Capillary or choke tube
2. Motor controls
   (*a*) Pressure control
   (*b*) Thermostatic control

The absorption refrigerators use the following types of controls:

1. Thermostatic controls
2. Heater gas controls
3. Water controls

87. COMPRESSION MACHINE REFRIGERANT CONTROLS:

The domestic refrigerators are almost completely automatic in operation and about the only manual care should be the defrosting of the cooling coil. To obtain this automatic operation, positive methods must be developed for operating the unit for proper refrigeration in the box and for controlling the electric motor which drives the mechanism. These refrigeration controls may be divided into three classes: (1) the

pressure control, (2) the temperature control, and (3) the volume or quantity control. It is their duty to maintain the temperature in the refrigerator box within specific limits of 35° F. to 45° F.

88. THE PRESSURE CONTROLLED EXPANSION VALVE:

The automatic expansion valve or pressure controlled expansion valve is a refrigerant control whose operation is controlled by the low side pressure of the system, and whose purpose is to throttle the liquid refrigerant in the liquid line down to a constant pressure on the low pressure side. The action of the valve is very similar to a spray nozzle, and while the compressor is running, the liquid refrigerant is sprayed into the cooling unit tubing. Because the cooling unit is never filled with liquid refrigerant, but rather a vapor, a system using an automatic expansion valve is called a "dry" system.

The pressure method is illustrated by Figure 93 and shows a flexible bellows connected to the needle of a needle valve and having cooling unit pressure on the inside with atmospheric or confined gas pressure on the outside. From the illustration it may be seen that as the pressure in the cooling coil decreases, the differences in pressures will open the needle valve and allow some refrigerant into the coil which, as it evaporates, keeps the box temperature within its design limits.

This opening of the expansion valve occurs only when the compressor is running because this is the only time the pressure is reduced enough. The expansion valve cannot flood the low side when the compressor is running, because as soon as the refrigerant vapor reaches the end of the cooling unit tubing, the motor control located there will stop the motor, and the pressure will immediately build up enough to close the expansion valve.

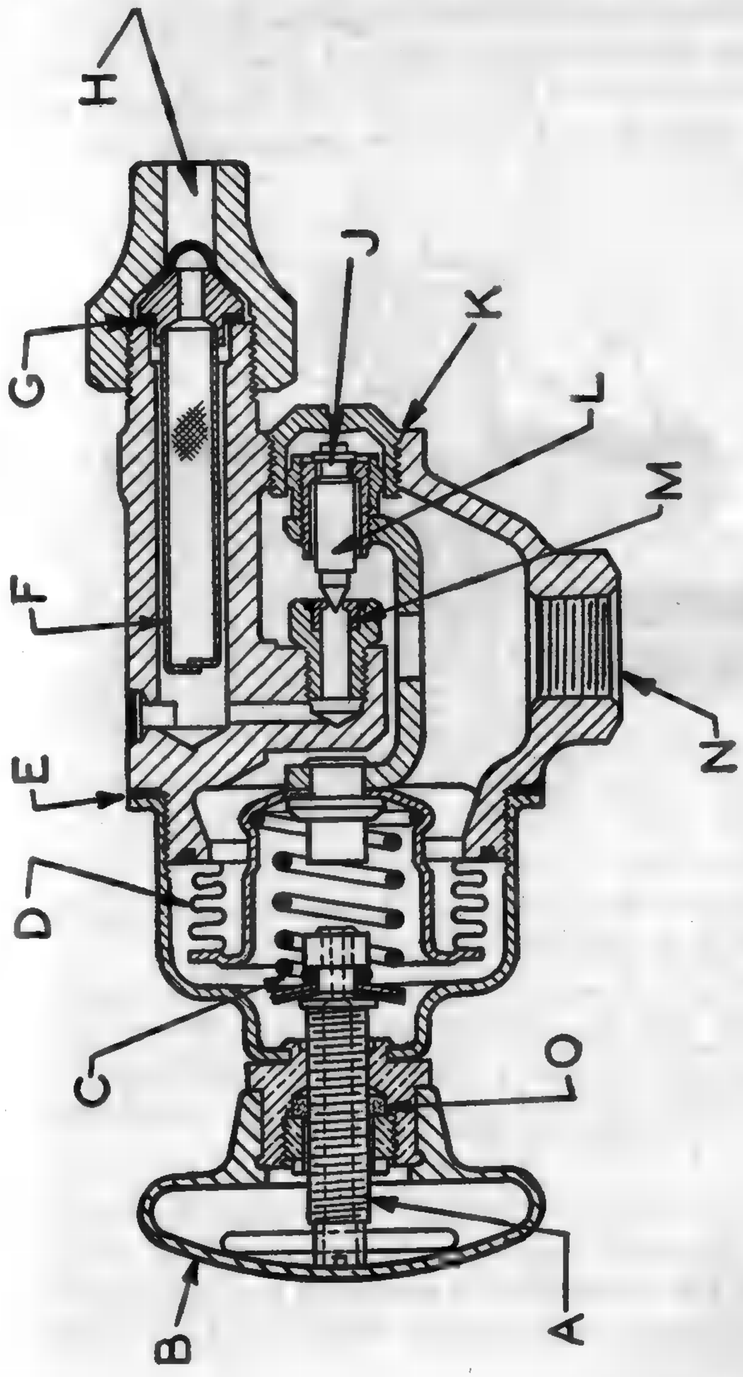


Fig. 93. A pressure-controlled expansion valve
A. Adjusting screw; B. Rubber cap; C. Lock joint; D. Bellows; E. Gasket; F. Screen; G. Plug; H. Liquid inlet; J. Needle shoulder; K. Plug; L. Needle; M. Seat; N. Refrigerant outlet; O. Packing
(Courtesy of: Detroit Lubricator Company)

These valves are adjustable to permit the opening of the needle valve over a varying range of pressures. Expansion valve adjustments must be made for varying altitudes as their operation is influenced by atmospheric pressure. An increase

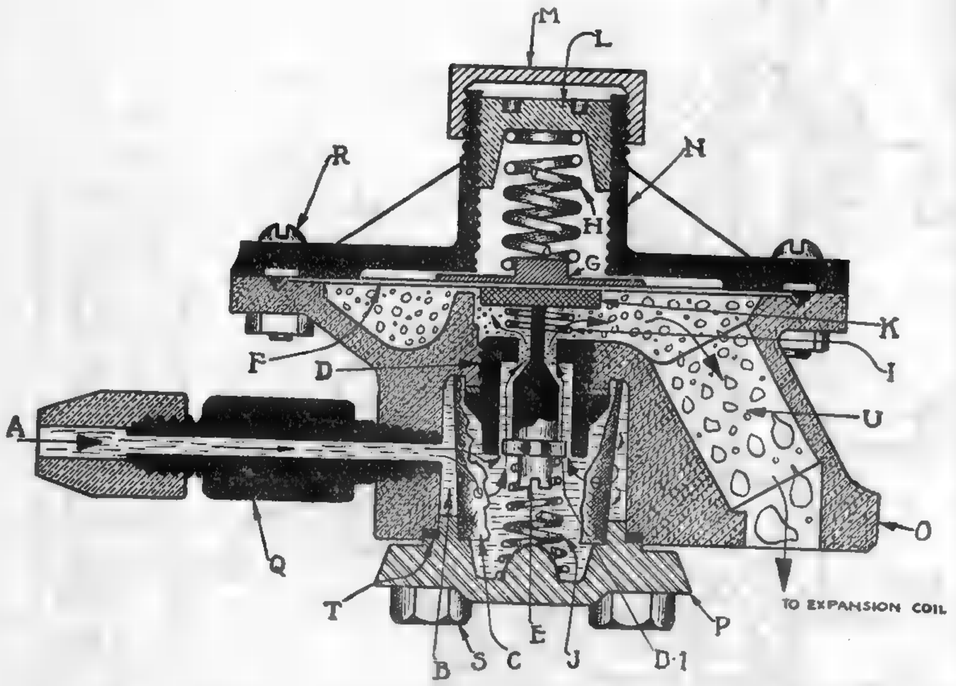


Fig. 94. An older type of pressure controlled expansion valve using a diaphragm disk in place of bellows

A. Liquid line connection; B. High pressure liquid; C. Screen; D. Valve seat; D-1. Valve seat proper; E. Valve needle; F. Phosphor bronze diaphragm; G. Spring retaining disk; H. Adjusting spring; I. diaphragm spring; J. Needle spring; K. Diaphragm needle disk; L. Adjusting screw; M. Adjusting cap; N. Adjusting mechanism body; O. Main body; P. Screen plug; Q. Liquid line adapter; R. Assembly machine screws; S. Assembly cap screws; T. A lead gasket; U. Low pressure vapor

in altitude will require screwing in the adjusting screw. Also different refrigerants require different expansion valve settings. Note the screen filter in the liquid line which will sometimes give trouble by becoming clogged. Also notice the

double spring arrangement on the needle so that the balanced pressures give a smoother control of the flow of the refrigerant. Figure 94.

To adjust these regulators, turn the adjusting screw out (contra-clockwise) which will release the spring pressure on the bellows and enable the needle valve to open only after a greater vacuum is drawn on this low pressure side. This will result in lowering the cooling unit temperature. To raise the cooling unit temperature turn the adjusting screw in (clockwise) because this will raise the low side pressure slightly. These controls can only be used with a thermostatic motor control. Figure 93 illustrates the latest type automatic expansion valves. The body is made of cast brass while the needles and seats are made of special alloys (usually Stellite needles and Monel metal seats). The valves always have softer seats than needles to eliminate as much as possible the wearing of a shoulder on the needle. The spring "C" is fastened at both ends, eliminating a spring inside the refrigerant space. The needle is mounted in a ball and socket to insure full seating. The bellows, made of special brass, are very flexible and are soldered to the body and disk. This bellows is made of stock .005 inch to .010 inch thick. The liquid line is usually 1/4 outside diameter (O.D.), and is fastened to the valve at "H" by a special nut permitting easy removal of the screen. Note how the bellows' external surface is sealed at "O," "F," and "B" to insure that moisture will not enter, freeze on the bellows, and interfere with the accurate operation of the valve. The diaphragm type expansion valve (Figure 94) has been discontinued because the diaphragm (F) after a certain period of use would buckle, and a snap-action would result. The valves are attached to the cooling coil either by means of fittings or two bolt flanges. Flanges sealed with lead gaskets are preferred.

89. LOW PRESSURE SIDE FLOAT CONTROL (FLOODED):

The second and one of the most popular methods of controlling the refrigerant flow is that used in the flooded system of refrigeration. It consists simply of a float which controls the amount of liquid refrigerant in the cooling unit. Figure 95.

The float is connected either to a needle valve or a ball check valve and is calibrated so that the valve will close

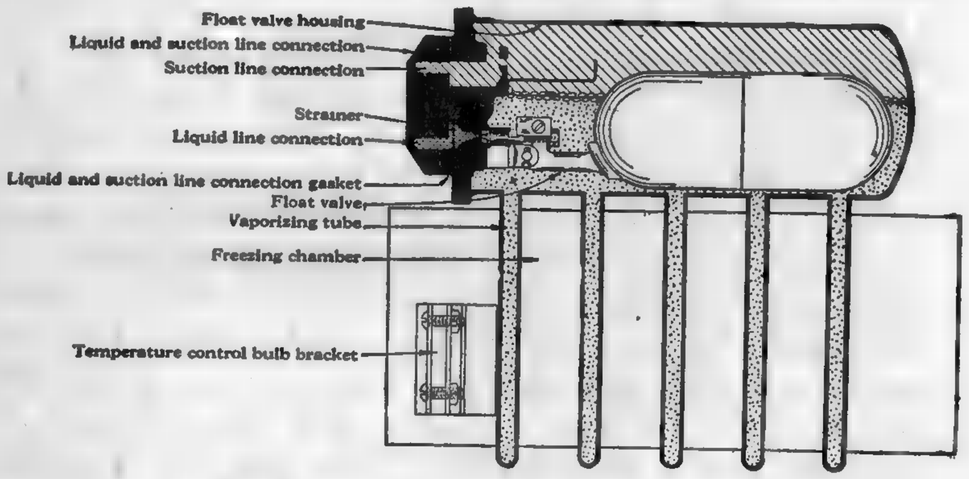


Fig. 95. A low-pressure side float control
(Courtesy of: Leonard Refrigerator Company)

when the float is at the proper level, that is, when there is enough liquid refrigerant in the cooling coil.

The suction tube of these cooling units extends into the float chamber and has its opening located near the top. This opening is also protected by having a baffle plate located between it and the liquid. This is necessary because the liquid as it evaporates is agitated violently; if this baffle plate were not provided, the suction tube would always have liquid refrigerant in it when the compressor was running. Figure 95.

These cooling coils, or boilers, are usually made of copper (tin-dipped). The float chamber has tubes running out of it and down, forming a box for the ice-cube trays; the tubing then returns to the float chamber. The joints are sealed by brazing or silver soldering, although some early types were soft soldered. The float itself is usually a sealed brass ball connected to the needle by means of a brass lever. The needles used in early refrigerators were made of steel, but are now made of stainless steel or Stellite. The seats are built into

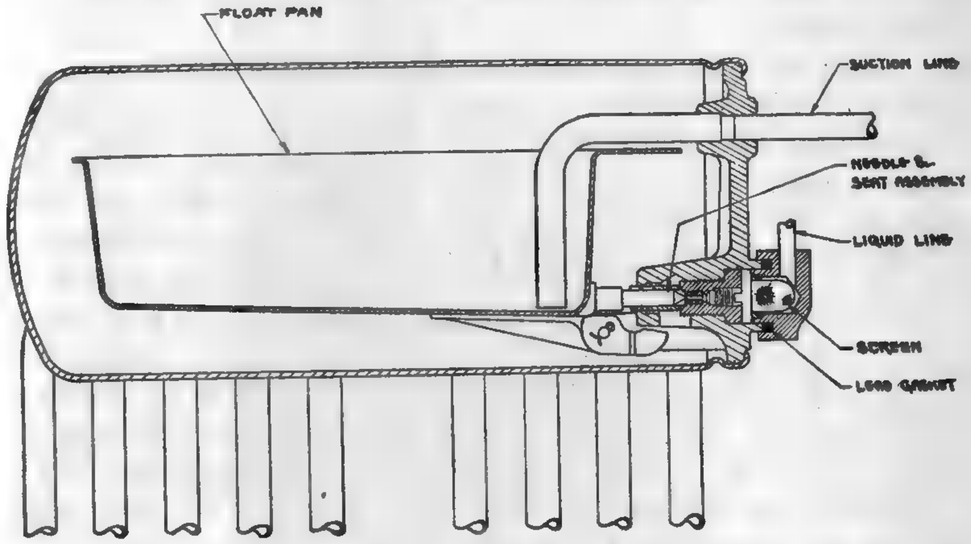


Fig. 96. A pan-type float control
(Courtesy of: Norge Corporation)

the removable header (Figure 25) and are made of brass, or Monel metal. Five to seven cap screws hold the header in place. A lead gasket is used to seal the joint because it is easily broken open, it takes up little space, it needs no cleaning upon removal, and it may be used again. The cap screws may be made of either Monel metal or cadmium plated steel to prevent rusting. Figure 96 illustrates the pan type or bucket type of float. This float is made of brass and operates

similar to the ball type. The header on this type of float is usually welded into place and cannot be removed. A cartridge type needle and seat assembly is therefore used. The ball type floats are used with most of the sulphur dioxide units and with the old methyl chloride units. The pan type float is now used with methyl chloride because it insures a more positive oil return. This is accomplished by extending the suction line into the bucket, since the oil collects in the open bucket as it settles out of the spray in the float chamber. One company uses a wick to remove the oil from the chamber into the bucket.

The low side floats must be very carefully adjusted or calibrated when assembled in order to control the liquid level at a certain definite setting in the cooling coil. If the float mechanism is adjusted so that the float will close the needle before the refrigerant level gets high enough, insufficient refrigeration will result together with a lower than normal low side pressure. Also, if the refrigerant level is too low, an excess accumulation of oil will take place in the cooling coil; this will oil-bind the refrigerant. If the float is calibrated so that the refrigerant level is too high in the cooling coil when the valve closes, some of the liquid refrigerant will be admitted to the suction line and a frosted line will result. This will increase the cost of operation of the machine.

These floats are adjustable either by bending the float arm as in Figure 23, or by having a special adjusting screw on the mechanism as illustrated in Figure 95.

Another feature to be noticed is that the oil in the sulphur dioxide units settles on the top of the refrigerant when it collects in the cooling unit because the oil is lighter than the refrigerant. The float must be designed for a certain oil layer and amount of refrigerant.

It is a peculiar phenomenon of refrigerants that if they are not agitated or helped in some other way, the pressures

may sometimes be reduced far below the refrigerant's boiling point at that temperature before the liquid will start evaporating. This peculiarity is greatly increased by the layer of oil always present on top of the refrigerant which acts as a choke or retarder.

Many methods have been promoted to prevent this occurrence; these include sawed tubing, tacks, and other materials which are placed in flooded cooling units. Some of these are

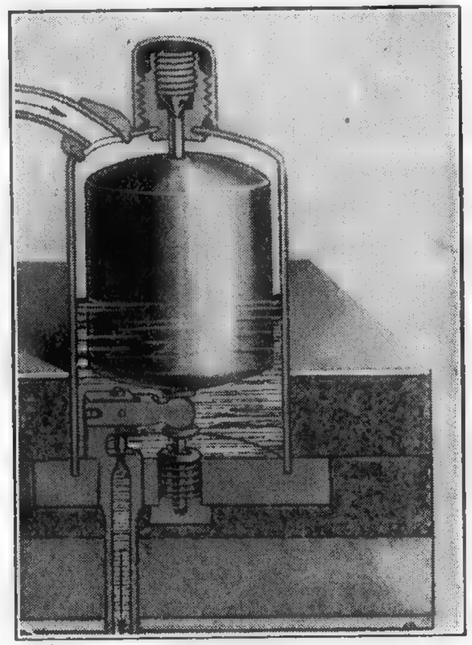


Fig. 97. A hermetic type high-pressure side float control
(Courtesy of: General Electric Company)

still being used, but the best development along this line has been the use of special wood which, when located in the liquid-filled tubes of the cooling unit, acts as a catalytic agent and always makes the refrigerant boil at the correct temperature. These substances are called ebulators.

The float control is practically fool-proof but occasionally the unit will stick either open or closed. A closed needle

valve may be detected by a lack of refrigeration, a high vacuum, and continuous running; and an open needle valve may be detected by a continuous hissing in the cooling unit after the compressor has stopped, an equalizing of the pressure gauges, and a frosted suction line. See Paragraph 211.

90. HIGH PRESSURE SIDE FLOAT CONTROL:

Another control that is similar in construction to the low pressure side float control, except that the float is located on the high side of the system, is the high side float valve. See Paragraph 62 and Figure 97.

The floats are made of copper or steel. In the hermetic or semi-hermetic units the steel type is used. These units cannot use a liquid receiver unless the float is located within it. These float controls do not have as much difficulty with oil binding as the low side float control because at the higher pressure the oil is dissolved more readily in the liquid refrigerant and circulates with it. However, the cooling coil used in connection with a high side float control must be equipped with a special oil return, or oil binding trouble will be encountered in it.

91. CAPILLARY OR CHOKE TUBE REFRIGERANT CONTROL:

An increasingly popular refrigerant control is the capillary or choke tube type. This control consists of a very small diameter coil of tubing which acts as a constant throttle on the refrigerant. It was first developed successfully for the Rice domestic refrigerator using methyl chloride, and is now being used by the Crosley Corporation. It is a peculiar control inasmuch as the amount of refrigerant in the system must be very carefully calibrated, for too much will make

the unit frost back. It must be used in conjunction with a thermostatic motor control. The Rice machine used a capillary tube 27 inches long and the diameter was 1/16 inch.

The 1934 and 1935 Frigidaire Standard line uses a refrigerant control similar in action to the capillary tube control. It is called a "Restrictor" and consists of a refrigerant passage formed by the threaded portion of a large diameter screw tightly enclosed in a housing. Figure 98.

92. CHECK VALVES:

Rotary and gear compressors are equipped with check valves in the suction line to prevent a backing-up of the high pressure into the cooling unit. Figure 99. These check valves

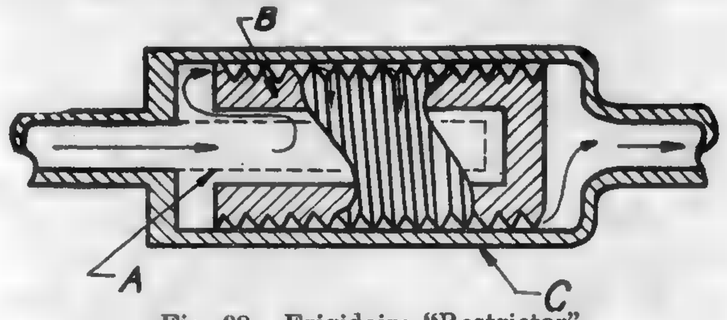


Fig. 98. Frigidaire "Restrictor"
A. Screen; B. Threaded Cylinder; C. Housing

may use either a disk or a solid ball in their construction. They may also operate differently; some use a spring to keep the valve against its seat, Figure 57, and others are mounted so that the weight of the valve keeps it against its seat. Figure 99 and Figure 60. The General Electric monitor top has a check valve serving a different purpose, i.e., to unload the compressor when it is starting. (See Paragraph 68.)

The check valve in the illustration (Figure 57) is equipped with shipping caps and the lower end screws into the suction service valve. Note the screen built into the check valve and the spring holding the disk check valve against its seat. The older models used a ball check valve.

93. REFRIGERATION ELECTRIC MOTOR CONTROLS:

The temperature inside the box is to be maintained within certain limits; therefore the machine must be shut off (cut-out) when the low limit of temperature is reached, or food will be spoiled by getting too cold; likewise when the box temperature rises again, the machine must start up (cut-in).

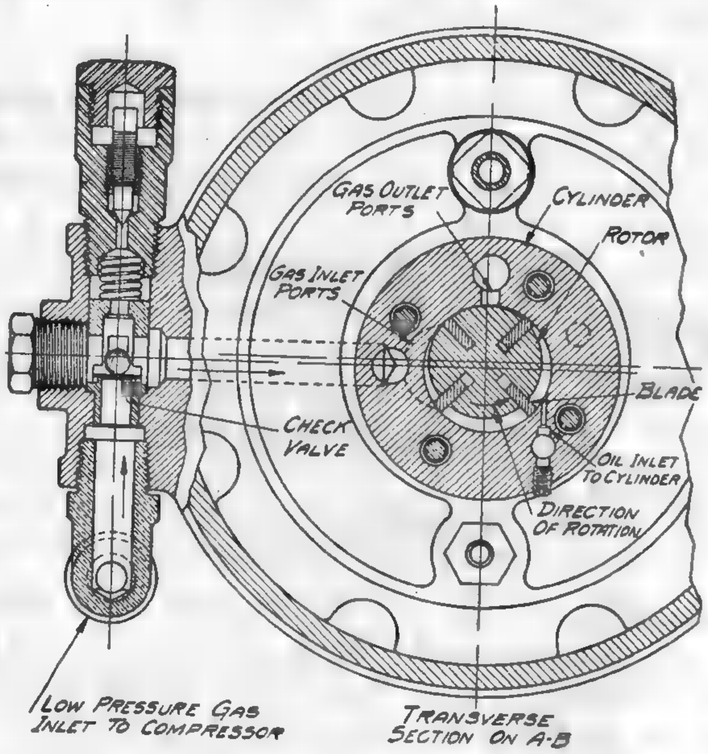


Fig. 99. A low-pressure side check valve
(Courtesy of: Sunbeam Electric Manufacturing Company)

To do this task we have in use two types of motor controls, the pressure type and the thermostatic type. The running time naturally varies depending on the room temperature. For the Northern states this running time is approximately 35 to 40 per cent of the time: for the Southern states the

running time may become approximately 50 per cent of the total for most refrigerators. In the older designs the unit would cycle over a two- to three-hour period. That is, the running time and off time of the mechanism would total between two and three hours. The trend recently has been to decrease the over all cycling time so that we now have refrigerators which run 5 to 10 minutes and are off 10 to 20 minutes.

Also, it is a standard practice among the manufacturers to design their units so that the electric motor operates only 14 hours out of the 24 or less, which is approximately 58 per cent of the time.

This fourteen-hour operating time is on the basis of the use of the box, and if the box is used more, the running time will be longer; if the usage is less, the running time is less. The average box runs far below 14 hours of the 24. The usual time is from 8 to 10 hours of the 24.

The motor control performs two functions: (1) it maintains certain temperature limits within the cabinet and (2) it controls the cycling time of the refrigerating unit. To adjust these two conditions we have (1) a range adjustment, the purpose of which is to make the box colder or warmer; and (2) a differential adjustment, the purpose of which is to adjust and regulate the running cycle of the unit.

94. RANGE AND DIFFERENTIAL ADJUSTMENT:

Usually the differential is made as large as possible to eliminate too much starting and stopping of the motor. The maximum differential adjustment comes when the box temperatures become too warm before the unit starts again.

A sample of a range adjustment is as follows: If the unit cuts-in at 25°F. and cuts-out at 15°F. cooling unit temperature, the range is the value of the two; the differential

is the distance between the two, 10°F. in this case. To make the box operate at a warmer temperature, the range adjustment is adjusted so the cut-out becomes 16°F. and the cut-in 26°F. Note that the temperatures are higher, but the distance between the two has not been changed; therefore the differential is the same. This condition will slightly affect the running time of the unit due to the fact that the box is not so cold now, and therefore, the condensing unit will not have to do quite so much work.

If the unit turns off and on too frequently and maintains a very good steady box temperature, the differential may be increased to allow less frequent starting of the motor by increasing the differential from 10°F. to 12°F. The differential is adjusted in three ways: (1) the cut-in point may be moved without changing the cut-out, (2) the cut-out point may be moved without changing the cut-in, (3) or they both may be adjusted farther apart or brought closer together. One will usually find one of these three different types of differential adjustments built into a control.

An example of (2) is to change the 15°F. and 25°F. adjustment to 14°F. and 25°F. Note that this will make the box become colder before it will cut-out; but by simply adjusting the range adjustment after the differential has been increased, one will get the same results as in the first type, (3) will change the 15°F. and 25°F. adjustment to 14°F. and 26°F. adjustment.

The range adjustment is easily recognized by the fact that it is a spring pressing directly upon the bellows which operates the switch; this spring pressure is always being exerted upon the bellows whether the switch is in the cut-out position or in the cut-in position. A differential adjustment of the first two types may be recognized by the fact that it affects the operation of the switch mechanism, in the first case, when the switch is in the cut-out position or in the second case,

when the switch is in the cut-in position. The third type differential adjustment, which is very common, is usually an adjustable arrangement which affects the effort of the toggle to snap off and on. Figure 100 has a differential adjustment affecting both the cut-out and cut-in simultaneously. Figure 101 has no differential adjustment while Figure 102 has only a cut-in differential adjustment.

95. PRESSURE CONTROL:

To have any refrigeration effect at all in the box, a low pressure must be maintained in the cooling unit to permit evaporation of the refrigerant at a low temperature. Therefore, one automatic control of the motor is based on pressure differences in the cooling unit. This is the old style domestic control and is not used on domestic models dating from about 1928. However, it is used extensively in the commercial field. It operates as follows: when the pressure builds up in the cooling unit, a switch is automatically thrown and the motor starts; then when the pressure becomes low enough, the motor is automatically shut off. Figure 100.

This switch is of either the mercury bulb or of the contact point type using a bellows-actuated toggle. Figure 100. As may be seen from the figure, a pressure rise in the bellows chamber will rotate the bell crank lever and allow the contact points to lower and touch the fixed electrodes. As soon as the motor reduces the pressure, the bell crank reverses its motion, pulling the contacts up and opening the circuit.

The range adjustment will lower the cut-in and cut-out an equal distance if the nuts are moved out (contra-clockwise) and will raise the cut-in and cut-out pressure if turned in (clockwise).

The differential adjustment separates the cut-in and cut-out pressures when turned farther to the right (clockwise) or vice versa.

The range adjustment spring is the one that is always pressing against the bellows or diaphragm of the control, but the differential spring or adjustment may be one of several different styles. In Figure 100 the differential spring is of the third type explained in Paragraph 94. That is, if the

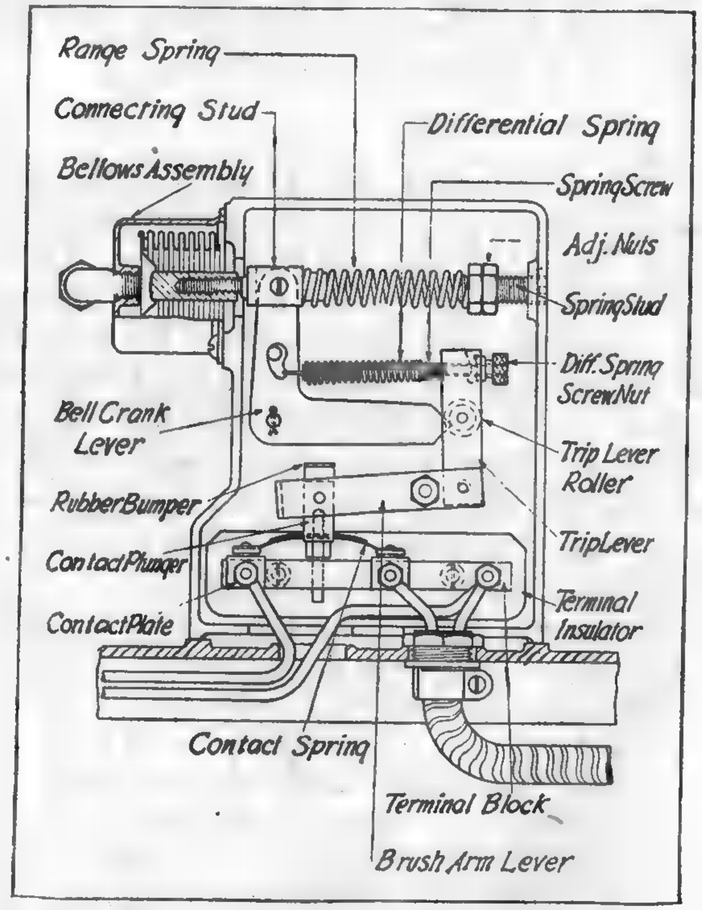


Fig. 100. A pressure-controlled motor control
(Courtesy of: Trupar Manufacturing Company)

spring tension is increased by turning the nut clockwise, it is harder for the bell crank lever to move over it, no matter in what direction it is moving. This naturally increases the distance between both the cut-in and cut-out points.

Some models of this particular control are also equipped with a safety control. It is of the bellows construction with a pressure tap to the high pressure side of the compressor so that, if the compression pressure should get too high, this bellows would throw the mercury switch out of contact, stopping the motor. This is only a safety device for the motor.

This type of control (the low pressure one) is of such a nature that it is easy to adjust while on the job, also it may be easily adjusted with a vacuum pump and a compound gauge after removal from the unit.

The adjustment of these controls is very important because lasting satisfactory operation of the unit depends a great deal on their accuracy.

96. THERMOSTATIC MOTOR CONTROLS:

Thermostatic motor controls may be classified into three types according to their internal construction and operation. These types are:

1. Thermostatic control self-contained type
2. Thermostatic control using a remote power element
3. Thermostatic control using a starting relay

The self-contained type (Figure 101) was one of the early developments in thermostatic motor controls. The thermostatic control using a remote power element is now used in the majority of refrigerators of conventional design. The thermostatic control using a starting relay is used only in hermetic machines.

Special devices such as over load cut-out, automatic defrosting, manual switch, and range adjustments which provide control of cooling coil temperatures are incorporated in most of the newer thermostatic motor controls.

97. SELF-CONTAINED MODEL:

The oldest design is shown in Figure 101 and from the illustration the operation may be explained as follows:

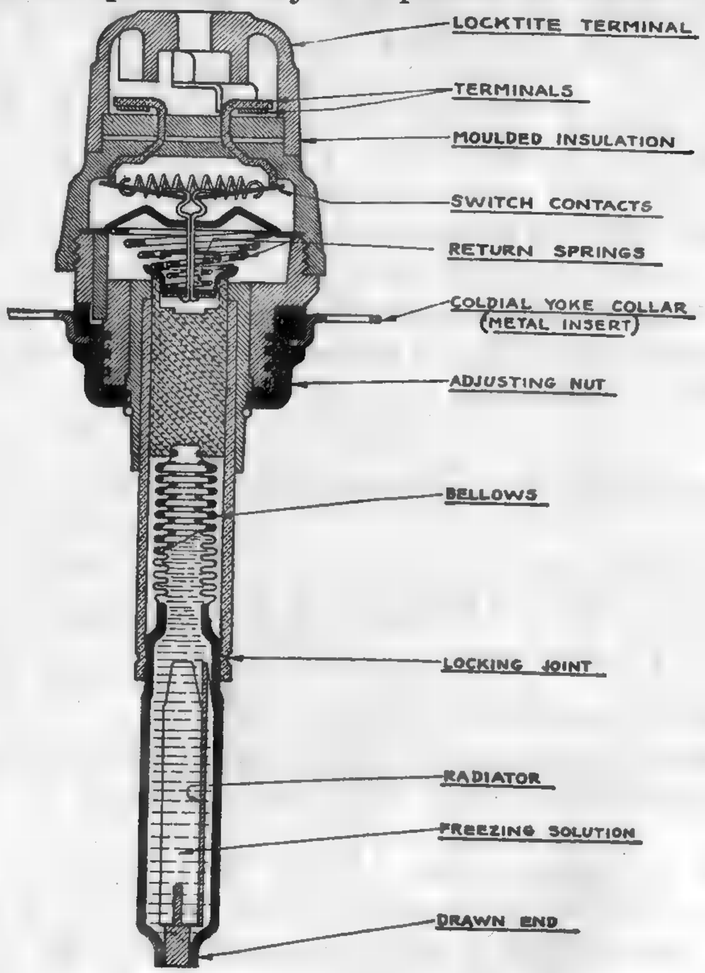


Fig. 101. A thermostatic motor switch
(Courtesy of: Copeland Sales Company)

The power element which is built in the lower part of the thermostat is clamped to the outlet tubing of the cooling

unit; as that power element warms, the fluid (alcohol and water) with which it is charged melts, and the pressure decreases upon the bellows located just above the power element. The pressure decrease naturally causes a contraction

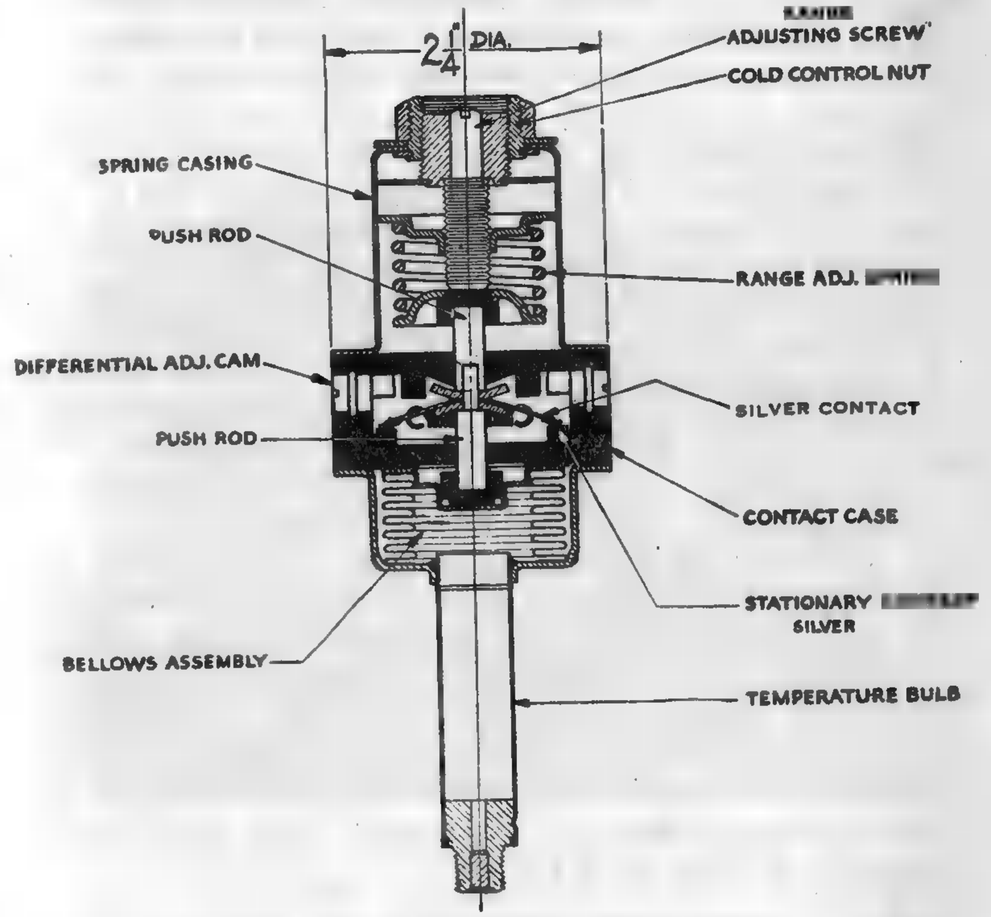


Fig. 102. A thermostatic motor control
(Courtesy of: The Bishop and Babcock Manufacturing Company)

of the bellows; this moves the two silver contact arms to a position where some small springs will snap them into contact with two fixed silver electrodes completing the electrical circuit and starting the motor. After the motor and

compressor have worked long enough to reduce the pressure, which in turn reduces the temperature in the cooling unit, the power element will become cold again (through thermal contact). This will result in an expansion inside the bellows due to the mixture freezing, causing the arm to fall, snapping the silver contact away from the fixed silver electrodes, opening the electrical circuit, and stopping the motor. The adjustment of this type of control is obtained by increasing or decreasing the spring pressure on the bellows causing it to cut-in and cut-out at different temperatures. It has no differential adjustment. To increase the difference in temperature between the cut-in and cut-out points, some models have small screws located in the side of the main body, but these should be adjusted only when absolutely necessary. Figure 102. This type of control uses the contact points instead of a mercury switch because this is permissible in the smaller models where the electric current load is not excessive and, therefore, the points will not burn out readily.

The power element in Figure 102 is charged with a refrigerant which works as follows: the power element, when warmed, expands the bellows, snaps the arms down, and starts the motor; when the cooling coil cools, the power element cools also, causing a decrease in pressure. When the pressure decreases enough, the point arms reach an in-line position, and the spring snaps them up a moment later. Note the range and differential adjustments. The differential adjustment is of the cut-in type.

98. REMOTE POWER ELEMENT TYPE CONTROL:

The new type of temperature control uses the very same principle, but in addition it is equipped with a safety-time fuse and a defrosting switch. Its design is different in this respect: it has a remote power element which is attached to

the electrical control by means of a capillary tube, but its operation is identical. That is, as the power element warms, its pressure operating upon a flexible bellows, located in the rear of the temperature control, presses against an arm under spring tension; when the pressure becomes high enough, it throws two silver contacts together completing the electrical circuit and starting the motor. Figure 103.

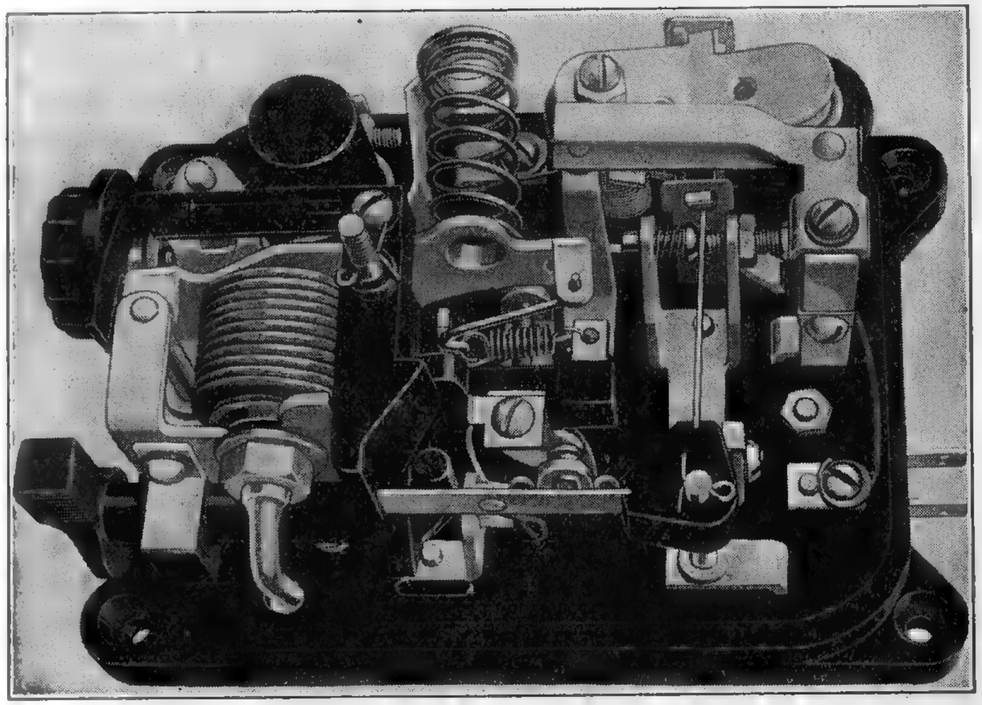


Fig. 103. A thermostatic switch equipped with starting relay
(Courtesy of: General Electric Company)

The bellows of Figure 103 may be found in the middle left-hand side of the illustration while the relay starting coil is located in the upper right-hand corner. The range adjusting knob is in the upper left corner; the contact points are in the lower middle just above the bimetal strip which buckles, when heated by the heating coil, the tops of which may be

seen. The buckling or bending of this strip stops the motor. The motor is of the induction type using three leads; and it has a special starting winding. This control is used only on hermetic refrigerators.

After the cooling unit has become cold enough the power element will cool; the resultant drop in pressure will cause a contraction of the bellows which in turn allows the spring pressure to make the silver contacts fly apart. These silver contacts are built into a lever toggle system controlled by springs so that when they are opened and closed they do it very rapidly with a snapping action. They are designed this way to reduce the arcing at the points. The adjustment of this temperature control consists merely in turning the knob in the direction specified on the cold control. Figure 104. That is, increasing the large spring pressure will make the unit warmer, and releasing the spring pressure will make the unit colder. To increase or decrease the temperature difference or differential between the cut-in and cut-out points, a small screw is located in the center of the large adjustment. The more tension put on the small screw (spring) the less the differential, and the less the spring tension (turning the small screw contra-clockwise) the more the differential. This is not to be touched, however, unless absolutely necessary.

99. DEFROSTING SWITCH AND FUSE:

The operation of the defrosting switch is as follows: To the defrosting switch button is fastened a long arm; when pulled out, this arm has a little catch on it which holds the silver contacts apart until the control button is pushed back again. A small ratchet rack and gear attachment are incorporated in a safety fuse or time fuse and operate as follows: directly in series with the wires going to the silver contact points is a heating coil which is wrapped around a shaft holding the ratchet gear. Figure 104. This coil is so designed that if the motor runs too long or draws too large a load, it will get so warm that it heats the solder holding the ratchet gear to the ratchet axle; when the solder gets hot enough

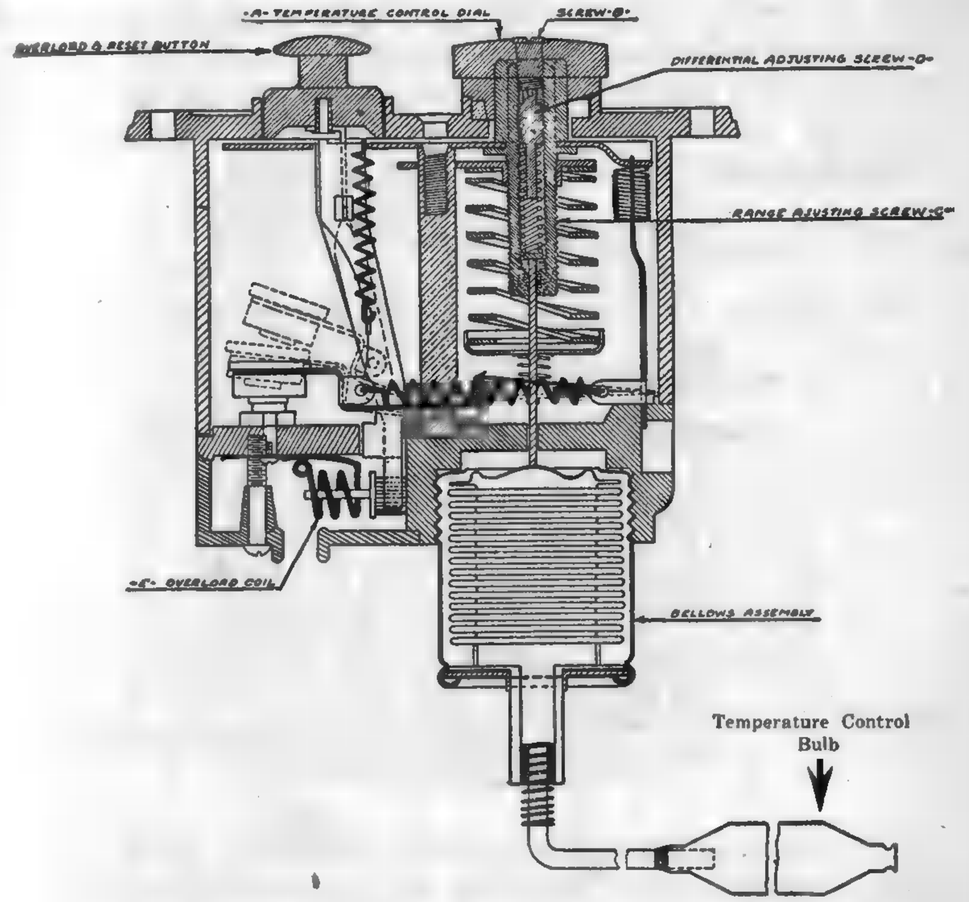


Fig. 104. A remote power element thermostatic control
(Courtesy of: The Sparks-Withington Company)

it will melt, freeing the ratchet gear. The ratchet rack has a spring tension on it and when released it pulls the rack up. This rack has a shoulder which catches the silver electrode lever, breaking the circuit. That is, as soon

as the solder melts, this arm will move up, pulling the defrosting button out and shutting off the electric motor. Naturally, as soon as the circuit is cut, the heating coil ceases to work, being in series with the rest of the electrical line, and the solder will resolidify so that when the housewife pushes the defrosting button back in, the outfit will work as before. This particular design is practically universal in the domestic models used today; for that reason its operation and adjustment should be very well understood.

100. TROUBLES:

The troubles that may be encountered in this particular

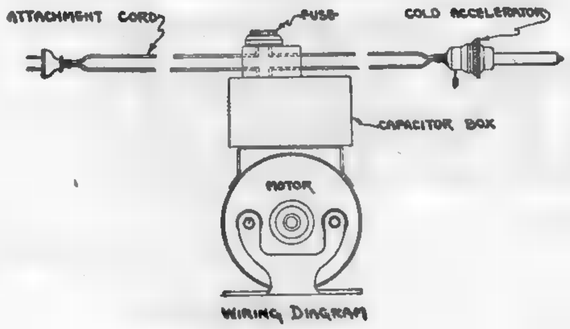


Fig. 105. The electrical connections of a thermostatic or pressure motor control
(Courtesy of: Norge Corporation)

switch are: (1) to have corrosion occur at the silver contact points causing a poor electrical circuit, which does not allow the motor to run. This trouble may be remedied by sanding the points with sand paper, *not emery cloth*, and it is advisable to use as fine a grade as can be obtained. (2) Be sure that the heating element on the ratchet axle is perfectly centered so that it does not touch the axle; also make sure that the coils of this heating element do not touch each other. (3) Another trouble frequently encountered in

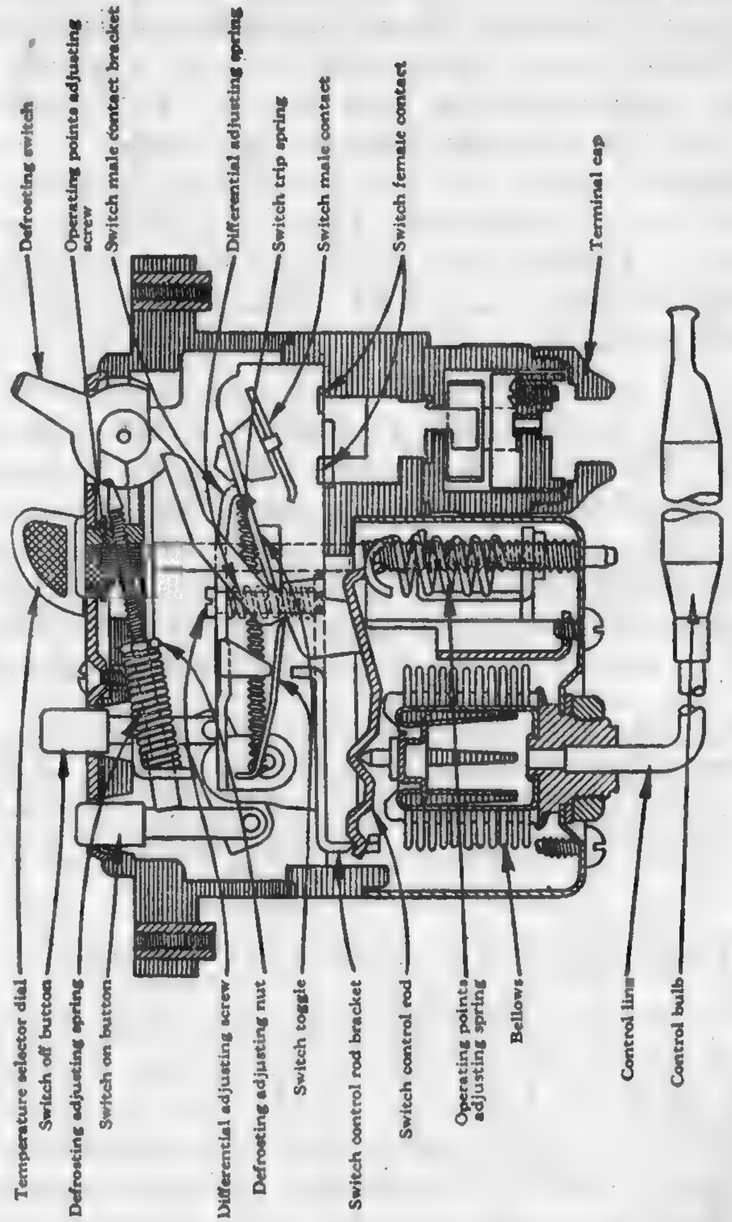


Fig. 106. An automatic defrosting motor control
(Courtesy of: Kelvinator Sales Corporation)

this type of switch is that the power element and bellows frequently lose their charge through some leak. This may be detected because if the charge is lost the bellows are very easily compressed with one's fingers. If the bellows were charged, the pressure inside would probably be around 75 pounds per square inch or more and finger pressure would not affect it. In the event of leakage replace this part of the switch. (4) Frequently the bellows is not screwed up tightly into the socket, causing a total change of temperature range before the motor will cut-in and cut-out. The servicing of these particular types of switches is rather difficult; it is therefore the best policy simply to replace the complete unit. The power element must be firmly clamped to the cooling coil at the suction line connection with an expansion valve unit, and on the side with a float or capillary tube unit. The heating coils for the safety device are of a certain size depending upon the motor capacity. The correct size must be used, or the safety device will not function correctly.

A further precaution to save the electric motor is an ordinary household fuse plug usually located near the electric motor itself. Figure 105 and Figure 144 illustrate the electric hook-up of the motor control and fuse plug.

101. AUTOMATIC DEFROSTING CONTROLS:

During the last few years various devices have been introduced incorporating automatic defrosting. The devices are made to do the following: (1) Defrost the unit, when the housewife presses the button, and return to ordinary operation automatically. The housewife has only to start the defrosting; the rest is automatic. (2) Another device uses a setting that permits a range adjustment. (A fixed definite one is made by pressing a button.) With this the cooling

coil will run at a warm enough temperature to permit defrosting, but will still give satisfactory refrigeration. (3) A third system incorporates a clock arrangement that will automatically (by time) start the defrosting and return the control to normal operation automatically. This type usually operates once every 24 hours. Figure 106 illustrates the first type and shows its interior construction. The range adjustment is the long screw with a moving nut. The nut is fastened to the switch control rod by means of the operating points adjusting spring. The differential adjustment controls the distance the toggle is allowed to snap open; therefore it adjusts the cut-in point.

102. ABSORPTION SYSTEM CONTROLS:

Most absorption refrigerators are water-cooled, which necessitates a water control mechanism. These controls are explained in detail later.

The method of heating may be by gas, liquid fuels, or electricity. At present gas is the most popular, and the method of controlling the supply is explained later. Of all the above the liquid fuel is probably the simplest; it consists merely of charging and firing the burners.

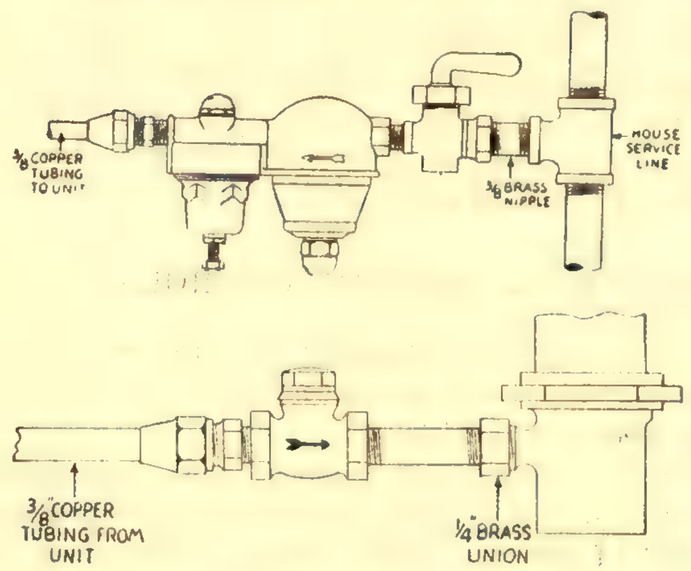
Aside from cabinet care and cleaning, the only service (outside the factory) that may be needed on the refrigerator is the water and heating controls. However, the adjustments determine the efficiency of the unit to such a great extent that these must be done carefully.

Water and heating gas valves are used in the absorption system to enable the automatic control of both the amount and pressure of the heating gas and water.

The systems use a continuous flow of water for cooling purposes; in some the gas flow is continuous and in others it is intermittent. There must be some correlation between

water supply and gas supply so that if the water supply is shut off or ceases to flow properly, the gas is shut off automatically. This should apply to all systems.

The water supply has its pressure reduced and the amount of flow is regulated by an adjustable valve. Great care is needed in the installation and adjusting of these valves,

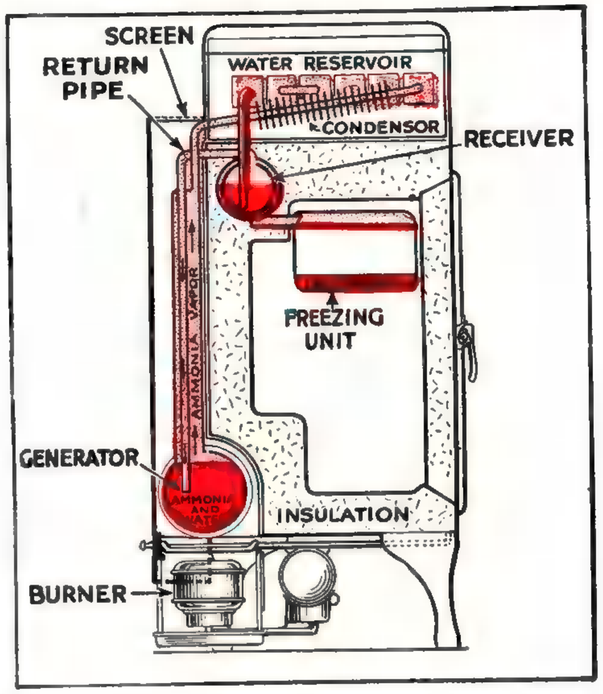


Drain Connection

Fig. 107. This shows the water line installation of a water-cooled absorption refrigerator unit. The body of the lower illustration contains a check valve.
(Courtesy of: Electrolux Refrigerator Sales, Incorporated)

because it is upon them that the economy and long life of the whole refrigerator depends. Figure 107.

The above refrigerators must also have a heating gas control of some kind. The Electrolux, being of continuous operation, has a gas volume control and two safety controls; one, a disk valve "Klixon," temperature-controlled by the flame itself, will automatically close the gas supply if



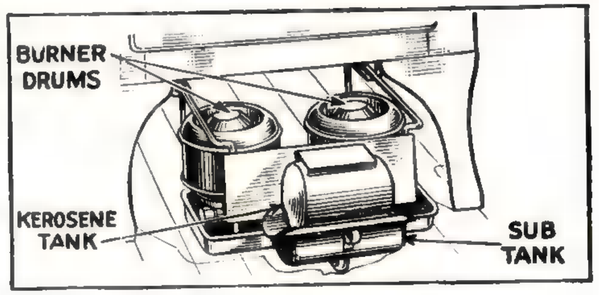


Fig. 90. The Trukold cycle and burners
(Courtesy of: Montgomery Ward & Company)

the flame goes out; and a bulb pressure temperature control will also automatically shut off the gas in case the water supply ceases. Another bulb pressure temperature control located at the cooling unit controls the amount of gas burned according to the needs of the refrigerator.

The gas control of the Faraday is somewhat different because the main gas burner is used intermittently and the gas to this burner must be turned on and off at proper intervals. This is accomplished by a pressure control valve and a trip valve to shut off and turn on the gas.

It is seen from the above explanation that a great deal of the successful operation of domestic refrigerators is dependent on the functioning of the automatic control valves; it is obvious that the more the service man knows of these valves and their troubles and remedies, the less difficult the servicing operations will be.

It is also important to know these controls perfectly for the reason that they must always be in excellent condition in order to give satisfactory, dependable service. It cannot be emphasized too much that these valves are the control board for the refrigerator.

103. GAS CONTROLS. (ELECTROLUX):

The Electrolux and Faraday refrigerators have their heat energy supplied by a gas burner, and several different methods have been devised for the regulation and control of this gas. In the Electrolux refrigerator, between the gas main and the operation controls of the refrigerator, are placed a manual shut-off valve, a strainer, and a pressure-regulating valve. Figure 108. As explained previously, the Electrolux operates on the continuous cycle and therefore the water and gas are continually being consumed. However, to take care of variations of demand on the refrig-

erator itself, the amount of gas fired must be automatically controlled. This is done by the use of a pressure control valve operated by a power element located at the cooling unit. This is designed so that as the cooling unit warms up, the gases in the power element (J) expand, and pressing upon a diaphragm in the control valve they open the gas control, which allows more gas to escape to the burner. Figure 109. The larger flame speeds up the cycle in the mechanism and continues to speed it up until the cooling unit has again become cold enough.

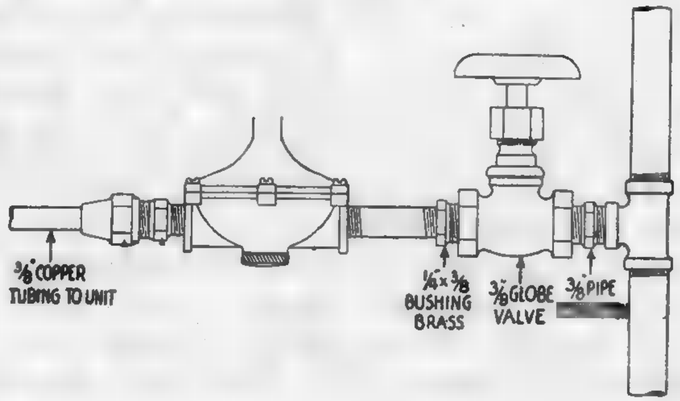


Fig. 108. The gas line installation of an Electrolux refrigerator
(Courtesy of: Electrolux Refrigerator Sales, Incorporated)

As the cooling unit cools, the power element located there will cool, reducing the pressure on the gas valve diaphragm. This reduction closes the heating gas opening, somewhat reducing the size of the flame. This valve operates similar to a temperature controlled expansion valve. Turning the adjustment clockwise or in, reduces the gas supply.

The water safety shut-off operates as follows: If by any chance the water circuit through the refrigerator mechanism is destroyed or stopped, another power element (E) located at the condenser becomes heated through the lack of cooling water, and exerts the pressure of its expanded gases upon

another diaphragm which completely shuts off the supply of gas, at (B) Figure 109. This is just a safety valve feature and is necessary because if the water supply were shut off and the gases allowed to continue burning, the refrigerator

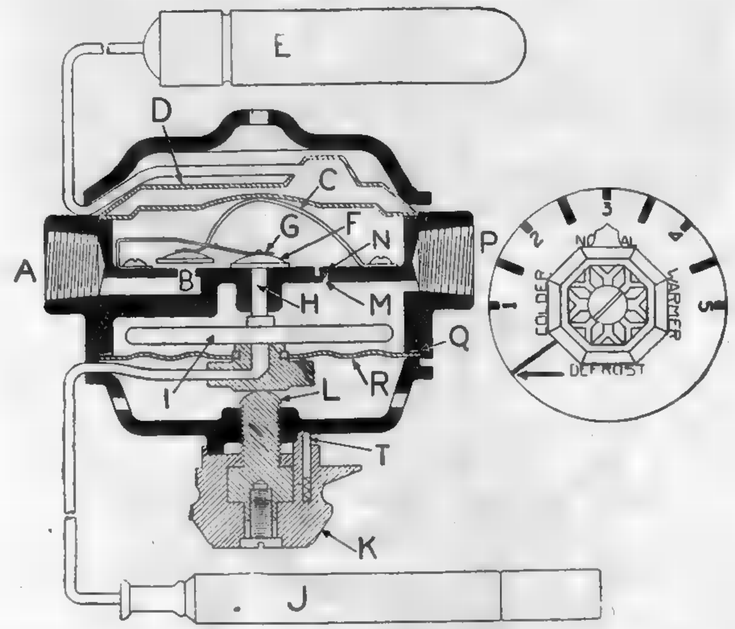


Fig. 109. The thermostatic gas control and safety shut-off used on the Electrolux water-cooled refrigerator

A. Gas in; B. Orifice; C. Safety button arm; D. Safety control diaphragm; E. Safety control power bulb; F. Thermostatic button; G. Button arm; H. Button actuating pin; I. Thermostatic diaphragm; J. Thermostatic power bulb; K. Manual temperature adjustment; L. Temperature adjusting screw; M. and N. By-pass for minimum flame; P. Gas connection to the burner; Q. Sealing diaphragm gasket; R. Sealing diaphragm
(Courtesy of: Electrolux Refrigerator Sales, Incorporated)

would not act as a refrigerator any longer and there would be a needless consumption of gas.

The Electrolux people have designed a unique valve for preventing useless waste of gas in case the light should be extinguished. This valve is of the dished-button type and

is thermostatically controlled. Figure 110. Being located adjacent to the flame it remains hot as long as the gas is ignited, but as soon as the flame is put out this disk (D) will become cold; it is so designed that if it does it will snap

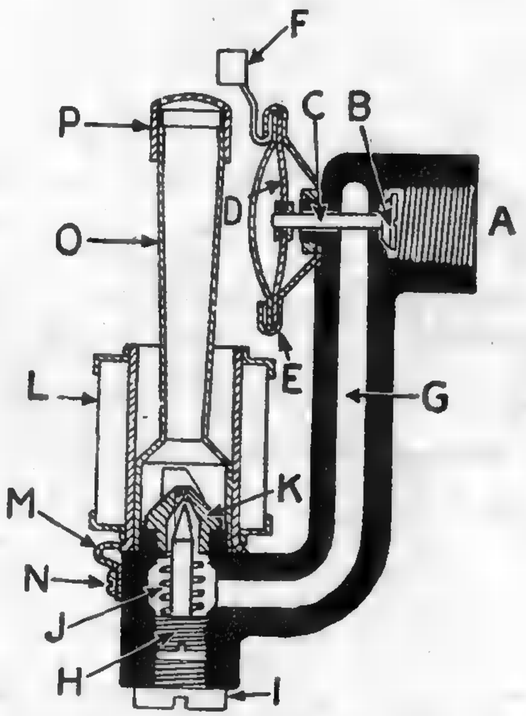


Fig. 110. The "Klixon" valve and the burner used on the Electrolux
A. Gas in; B. Poppet valve; C. Poppet valve stem; D. "Klixon" snap button; E. Retaining housing; F. Klixon disk heater; G. Gas passage to the burner; H. Manual adjusting screw for maximum gas flame; I. Seat cap; J. Spring; K. Gas nozzle; L. Screen; M. Screen retainer; N. Screen retainer screw; O. Burner venturi; P. Burner cap
(Courtesy of: Electrolux Refrigerator Sales, Incorporated)

and become dished in the other direction. This movement closes a valve (B) in the gas line, completely shutting off the supply of the gas. If this happens, the only method possible of re-igniting the gas is to heat up this Klixon disk in order that it will open the safety valve again. This

may be done with a match and a special burner provided for this purpose.

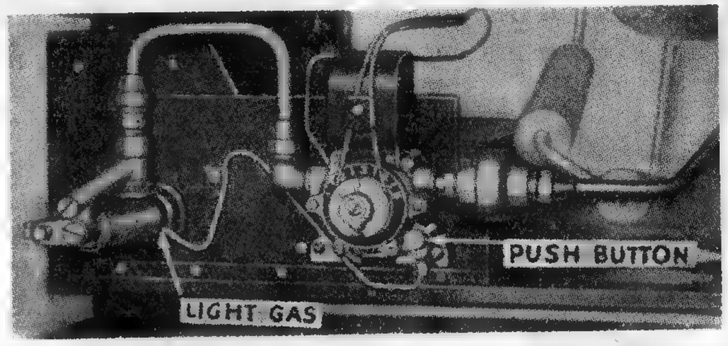


Fig. 111. The air-cooled Electrolux gas burner and control assembly
The instructions shown on the illustration are for starting the gas flame
1. Press the button; 2. Light the gas
(Courtesy of: Electrolux Refrigerator Sales, Inc.)

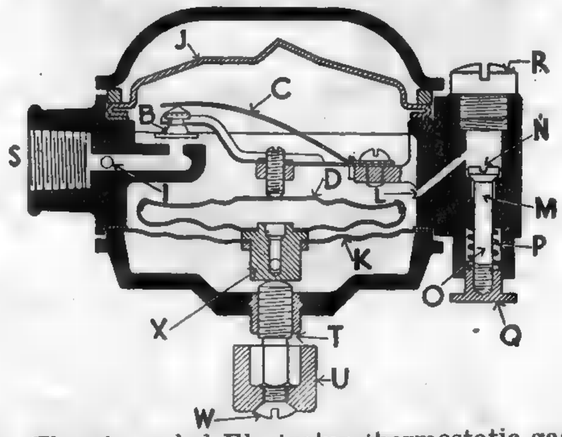


Fig. 112. The air-cooled Electrolux thermostatic gas control
B. Maximum flow valve; C. Maximum flow valve spring assembly; D. Thermostatic diaphragm; I. By-pass outlet; J. Body gasket sealing diaphragm; K. Sealing diaphragm; L. Burner lighter passage; M. Opening to burner lighter; N. Burner lighter valve; O. Burner lighter valve stem; P. Burner lighter valve stem; Q. Burner lighter push button; R. Burner lighter cap; S. Gas outlet; T. Thermostat adjusting screw; U. Thermostat adjusting screw knob; W. Set screw; X. Diaphragm and bulb assembly
(Courtesy of: Electrolux Refrigerator Sales, Inc.)

With each refrigerator the customer is supplied with an automatic pressure control for maintaining a constant gas

pressure. The reason for this valve is the fluctuation in pressures which is always existent in the gas mains all over the country, and because the supply of this gas must be very constant when being fed to the Electrolux. Figure 113.

104. THE AIR-COOLED ELECTROLUX GAS CONTROL: The air-cooled Electrolux has some refinements built into

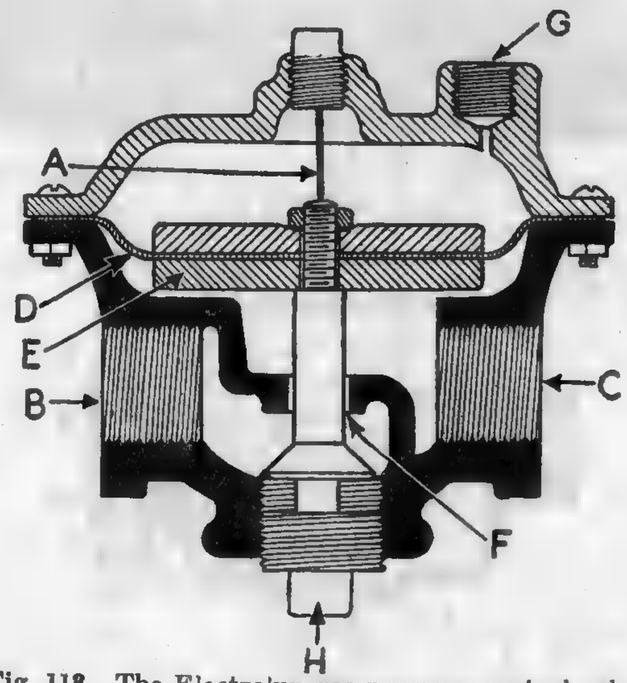


Fig. 113. The Electrolux gas pressure control valve
A. Shipping pin; B. Gas in; C. Gas connection to the thermostatic control; D. Flexible diaphragm; E. Weights; F. Valve and seat; G. Bleeder connection; H. Valve cap
(Courtesy of: Electrolux Refrigerator Sales, Inc.)

the gas control. The thermostatic control has a remote cold adjustment located at the cooling coil which is connected to the gas control by means of a cable. Figure 111. Another new feature is the burner lighter. As shown in the illustration a button-operated gas jet may be lit by pressing the button and this gas flame in turn will heat the "Klixon"

valve causing it to snap open, and the lighter flame will then ignite the burner. Note the filter located at the inlet end of the thermostatic control. Figure 112 shows the internal construction of the thermostatic gas control, illustrating the

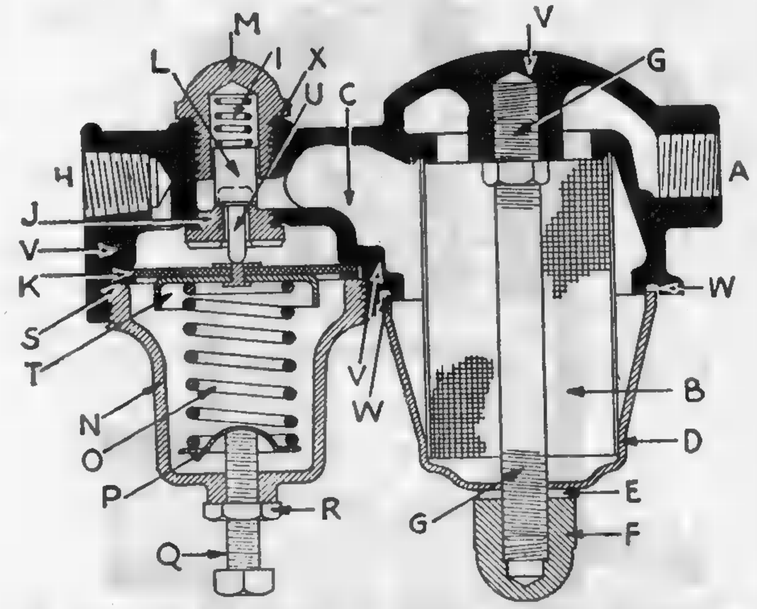


Fig. 114. Water strainer and pressure regulator used on the Electrolux water-cooled unit
A. Water in; B. Strainer; C. Water passage to the pressure regulator; D. Strainer retaining housing; E. Gasket; F. House retaining cap; G. Housing retaining stud; H. Water connection to the unit; I. Valve stem spring; J. Valve seat; K. Diaphragm; L. Valve stem; M. Valve retaining cap; N. Valve adjustment housing; O. Valve adjusting spring; P. Valve adjusting spring holder; Q. Valve adjusting screw; R. Valve adjusting screw lock washer; S. Gasket; T. Diaphragm protector; U. Valve actuating pin; V. Main body; W. Stainer housing gasket
(Courtesy of: Electrolux Refrigerator Sales, Incorporated)

gas by-pass for minimum flame, the burner lighter push button and valve, and the temperature adjustment.

105. WATER CONTROL (ELECTROLUX): The water supply to the condenser of the Electrolux must be regulated and controlled by means of a manual shut-off

valve, a strainer, and a pressure control valve. Figure 114. To obtain economy of operation in regard to water con-

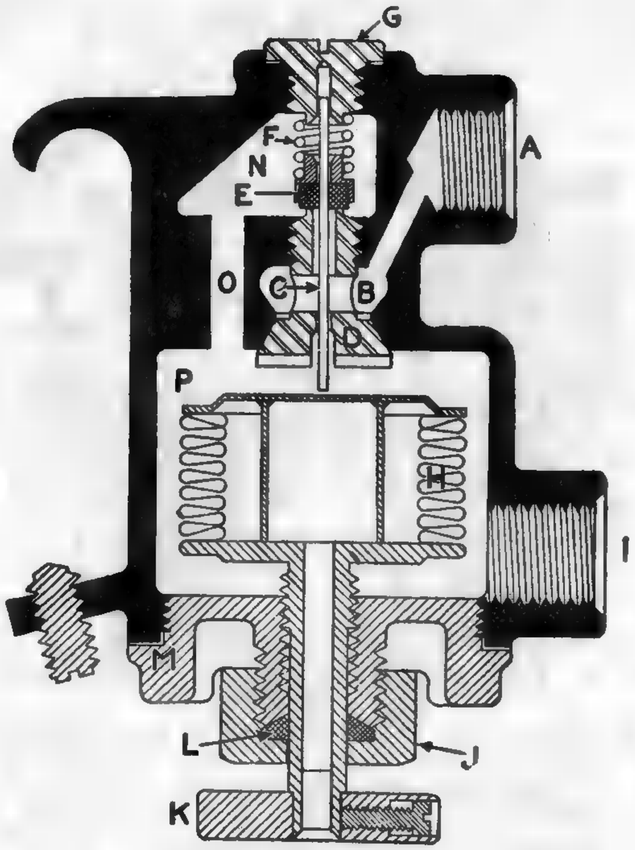


Fig. 115. The Electrolux automatic water flow regulator located at the outlet end of the condenser

A. Water connection to the condenser; B. Water passage to the valve; C. Valve actuating pin; D. Valve seat; E. Valve; F. Valve spring; G. Valve cap; H. Valve actuating bellows; I. Water connection to the drain; J. Packing nut; K. Adjusting screw; L. Packing; M. Removable housing; N. O. and P. Main water flow passageway

(Courtesy of: Electrolux Refrigerator Sales, Incorporated)

sumption, a water regulating valve is placed in the *outlet* end of the condenser. Figure 115.

As may be seen from the figure, this valve is operated by a pressure sylphon (H) which fluctuates as the temperature of the water increases or decreases. This special valve has a small by-pass (B) allowing a small flow of water continuously, and this small flow passing over the sylphon is

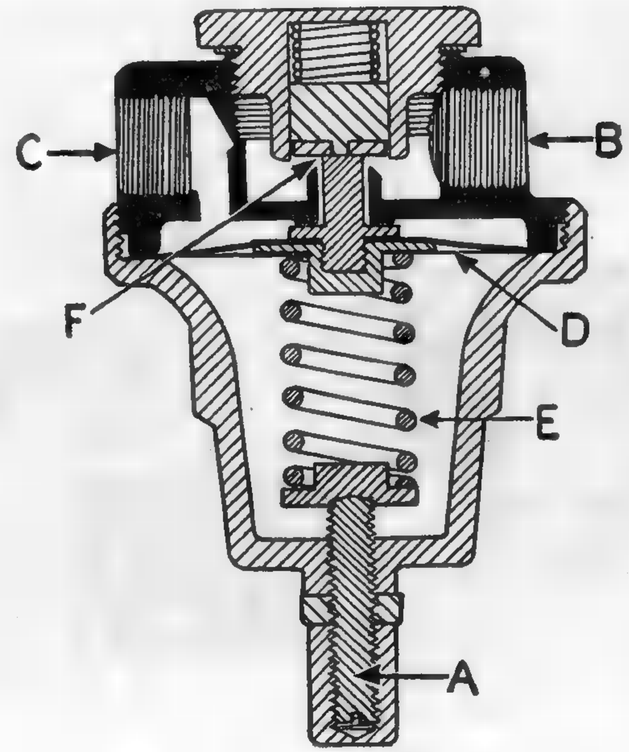


Fig. 116. Water pressure regulator

A. Adjusting screw; B. Water in; C. Water connection to the unit; D. Diaphragm; E. Adjusting spring; F. Valve

(Courtesy of: Electrolux Refrigerator Sales, Incorporated)

the heating medium. When the water in the condensing tubes becomes warm, this small flow also becomes hot, and passing over the sylphon causes it to expand, allowing a larger flow (flush flow) of water out of the condenser. This continues until the water reduces in temperature enough to make the

sylphon contract, closing the main orifice of the valve. This valve is complete within itself.

The water line is also provided with a pressure reducing or regulating valve to reduce the water pressure before it

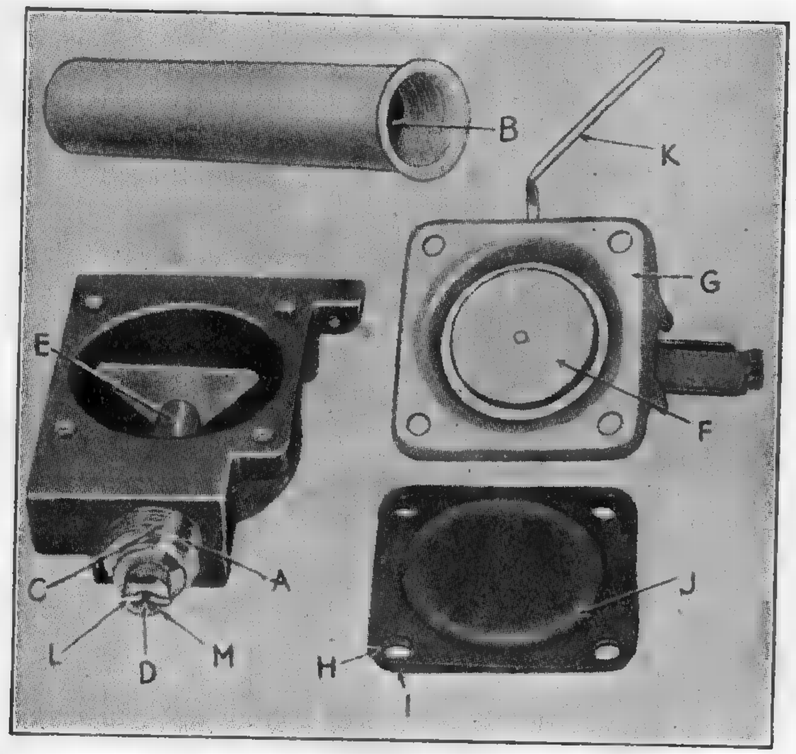


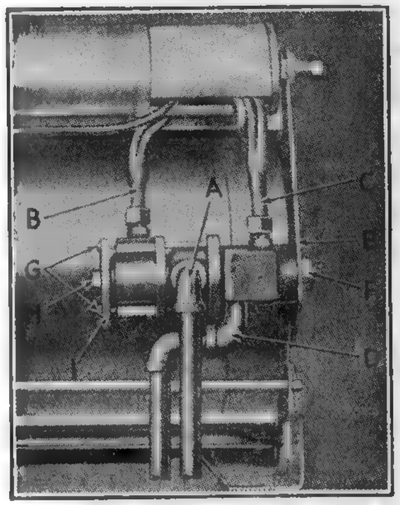
Fig. 117. The Faraday gas pressure regulator
A. Gas enters; B. Gas filter; C. Filter holder; D. Gas opening; E. Regulator valve; F. Valve weight; G. Valve weight holder and top of regulator; H. Diaphragm; I. Rubber gasket; J. Bulge of diaphragm toward weight; K. Vent to pilot light; L. Valve spring; M. Pressure adjusting nut
(Courtesy of: Faraday Refrigerator Corporation)

gets to the condenser. Figure 116. This valve operates and is adjusted like all automatic expansion valves. The Electrolux people have designed several of these valves, all operating on the same principle.

106. GAS CONTROL (FARADAY):

The Faraday refrigerator is also supplied with manual and automatic controls for the gas and water supply. The gas supply regulation is explained in Chapter VI, because it is part of the principle of operation of the refrigerator.

The gas pressure regulator is adjusted for 2 inches water column pressure with gas flowing and 2.3 inches of water



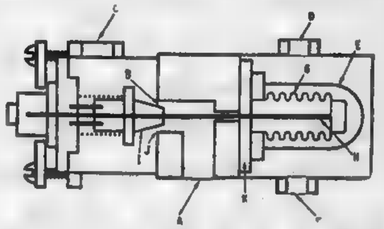


Fig. 119. Section diagram of the Faraday water control valve
A. Water in; B. Valve opening; C. Water into condenser; D. Water from condenser; E. Operating gas shell; F. Water to drain; G. Operating sylphon; H. Operating rod; I. Valve; J. Valve seat; K. Assembly flange
(Courtesy of: Faraday Refrigerator Corporation)

Fig. 118. The Faraday water control valve
A. Water in; B. Water into condenser; C. Water from condenser; D. Water out; E. Holder fitting; F. Nut to fasten valve; G. Assembly nuts; H. Adjusting screw; I. Assembly fixture
(Courtesy of: Faraday Refrigerator Corporation)

column pressure with no gas flowing. This is the dead weight type of regulator.

The large filter is used to clean the gases. See Figure 117.

107. WATER CONTROL (FARADAY):

The water control is distinctly of Faraday construction and operates as follows:

The water valve controls the water as it enters the con-

denser and the valve itself is controlled by a sylphon which is surrounded by the exhaust water; that is, the valve has four water connections, two for the water going into the condenser and two for the water coming out of the condenser.

As the exhaust water warms up, it heats the sealed liquid surrounding the sylphon in the water valve. This closes the sylphon, opens the valve, and permits a greater flow of water into the condenser. As soon as the temperature of the exhaust water lowers the sylphon will expand, closing off the orifice which will cut down the amount of water flowing through the condenser.

Adjustment of the valve is obtained by turning in screw (clockwise) to raise the outlet water temperature, that is, making it harder to open the valve.

The outlet water temperature should be 90°F. with the burner working and the water flow should almost cease with a 10°F. drop in the exhaust water temperature.

108. TEMPERATURE CONTROL FOR THE FARADAY:

This control is explained in detail in Chapter VI. It is controlled by means of a cord attached to the pressure lever operating it. This cord runs up the front corner of the cabinet and is attached to a dial. The housewife can obtain any desired temperature in the cabinet by turning the dial. Paragraph 82.

109. REVIEW QUESTIONS:

Answers to the following questions may be found on page 811.

1. Explain A, D, H, L, and O of Figure 110.
2. What kind of motor control must be used with an automatic expansion valve? Why?

3. Why must a screen be located in the liquid line ahead of the refrigerant control needle?
4. Why are the pressure and the thermostatic types of motor controls essentially similar?
5. What two purposes does a motor control serve?
6. What happens in a water-cooled Electrolux if the water is shut off?
7. How many types of differential adjustments are there?
8. What is meant by float calibration?
9. Why must the gas pressure be carefully regulated in a gas-burning refrigerator?
10. Why does the suction line extend to the bottom of the pan type float?
11. What are thermostatic motor control bulbs charged with?
12. Why are starting relays used in connection with hermetic motor controls?
13. Why are automatic expansion valves made adjustable?
14. What are expansion valve needles made of?
15. What two types of floats are used in low side float systems?
16. Which refrigerant controls require the most accurate weighing of the amount of refrigerant used?
17. What does the range adjustment control?
18. What does the differential adjustment control?
19. Name the common defrosting devices.
20. What provisions are built into the motor controls to protect the motor from overloading?

CHAPTER VIII

DOMESTIC REFRIGERATOR ELECTRIC MOTORS AND GAS SUPPLY

Many types of electric motors have been used with refrigerating mechanisms. The most popular types used are:

1. The repulsion-start induction motor
2. The capacitator motor
3. The induction motor
4. The direct current motor

The repulsion-start induction motors have been used since 1918 and were the only motors recommended for the conventional belt-driven compressor until a few years ago. One exception was an early Copeland unit, which used an induction motor on a belt-driven unit and had a centrifugal clutch pulley which allowed the motor to start without a load. Direct current motors are used in localities which are only supplied with direct current. The capacitator motor is now being used extensively in place of the repulsion-start induction motor. The simple induction motor is used almost exclusively in the hermetic machines with a starting winding to take up starting loads.

110. REPULSION-START INDUCTION SINGLE PHASE MOTORS:

The repulsion-start induction motors have long been very popular where intermittent operation is needed such as in refrigerators, washing machines, oil burners, etc. The motor is an induction motor with a special winding in the armature to give it a high starting torque. The motor starts as a repulsion motor using brushes and the armature winding. As soon as it reaches a specified speed the armature windings are shorted, the brushes are lifted from the commutator, and the electrical current goes only through the field windings. Figure 120.

These brush lifting motors usually have a radial commutator. Some of the motors do not lift the brushes but simply short circuit the commutator. Such motors usually have a cylindrical commutator.

111. FOUNDATION:

A solid substantial foundation should be provided for the installation of any motor. When the motor is mounted upon the foundation, it should be bolted down securely; when so fastened the armature shaft should be level for a horizontal motor and should be plumb for a vertical motor.

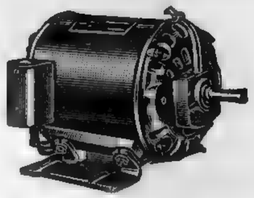


Fig. 120. A repulsion-start induction electric motor
(Courtesy of Wagner Electric Corporation)

Refrigeration motors are commonly mounted on a steel base which also holds the compressor and condenser. A rubber or spring suspension is often used to reduce the vibration and to take up the starting torque. Some motors are mounted on a cradle and a spring is used to give automatic belt tension. A new innovation is to mount the motor on a cradle in such a manner that, as the motor starts, the extra torque tightens the belt, and the belt tension returns to normal when the motor reaches its full speed.

112. BELTS:

When the motor is belted to the driven machine, it is necessary to have both shafts parallel to make the belt ride properly upon the pulleys.

Whenever possible the direction of rotation should be such as to cause the pull to be on the bottom side of the belt.

113. DIRECTION OF ROTATION:

Excepting for the reversible motor, the direction of rotation is changed by shifting the brush-holder. See Figure 121. This is accomplished by loosening the set screw at the side of the bearing housing on the commutator end of the motor, and moving the pointer to one of the lines or notches at the side of the slot. For right-hand, or clockwise rotation,

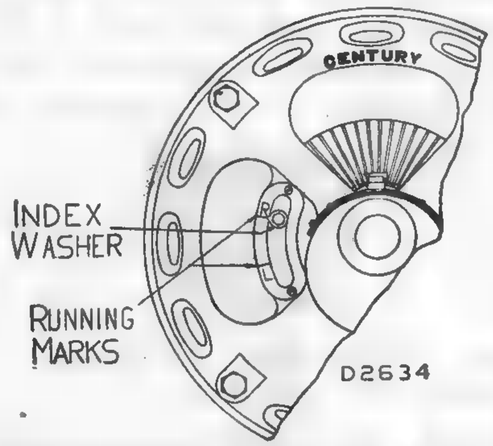


Fig. 121. The "Century" method of reversing the direction of rotation of their repulsion-start induction motors
(Courtesy of: Century Electric Company)

place the pointer at the line marked "R". For left hand or contra-clockwise, rotation, place the pointer on the line marked "L". The letters "R" and "L" do not appear on some of the smaller motors. In those cases, move the pointer from the middle of the slot in the direction the armature should rotate and place it opposite the mark nearest that end of the slot. The pointer should be exactly on the line for the best results.

The method of reversing the motor varies with the manufacturer, but the fundamentals are the same. The direction

of rotation of direct current motors is reversed by reversing the leads or wires which connect to the field windings.

114. WOOL YARN SYSTEM OF LUBRICATION:

Motors equipped with this system of lubrication, when shipped from the works, have the wool yarn saturated with oil. However, before starting the motor, fill the oil wells by adding slowly to each oil well at least the amount of oil designated on the tag attached to the motor. Figure 122.

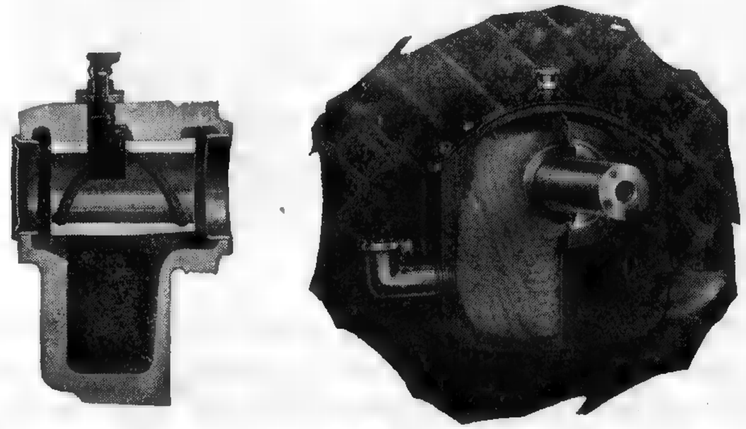


Fig. 122. The typical wick oiled bronze bearing used on refrigeration motors
(Courtesy of: Century Electric Company)

If the bearing is removed from the shaft, the yarn should be lifted from the bearing before replacing to prevent its being forced between the shaft and the bearing. When replacing the yarn, an equal amount should be packed on each side of the bearing and so located over the slot of the bearing that the spring on the oil well cover will press the yarn down on the shaft. Wick lubricated bearings should be oiled every six months. Many of the older model refrigeration motors used the ring lubricating method. A brass ring rests on the motor shaft through a hole in the bearing. The ring is large enough to dip into the oil pocket below. As the

motor shaft turns, the ring revolves slowly and the wet portion lubricates the bearing. One must be sure to check the rings when working on these motors. Use a medium grade automobile oil for a lubricant.

115. BALL BEARING GREASE LUBRICATION. ROLLER BEARING GREASE LUBRICATION:

New motors are supplied with enough grease in the bearings to lubricate them for a number of months. A small amount of grease should be added every two or three months. Use a high grade "Medium" grease on fully enclosed motors. Too much grease will overheat the bearings. The life of the bearing depends on cleanliness; use only clean grease and keep all dirt and flying particles out of the bearing.

116. VOLTAGE CONNECTIONS:

Excepting for reversible and some special motors, motors are usually provided with four terminals for connecting the motor to one of two different voltages. One voltage is always twice the other, such as 110/220, 200/400, etc.

Either 110 or 220 volts (or such other corresponding voltages) are equally satisfactory, providing the voltage is maintained at the motor terminals; they may be used on circuits having voltage 100 to 120 or 200 to 240 volts. Since it is common practice in the installation of small motors to install wires with a view to mechanical strength, it is recommended that as far as possible, all motors be installed on 220-volt service; for if the wires are of liberal size, it will result in more certainty of good voltage at the motor terminals and especially when the motor may be overloaded. The maintenance of proper voltage at the motor terminals is absolutely necessary. Low voltage results in a rapid dropping off in horsepower capacity of any motor, since the

power that an alternating current motor will develop varies directly as the square of the voltage impressed at the motor

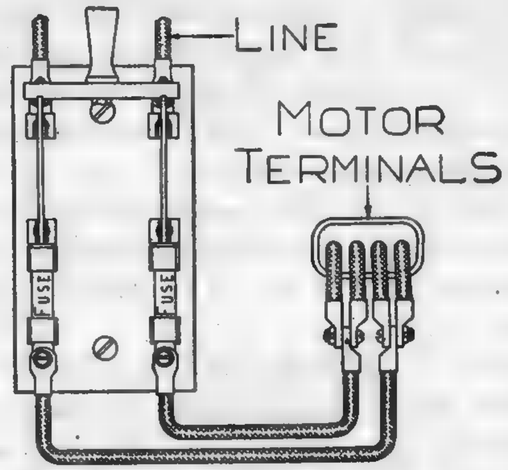


Fig. 128. The method of wiring a 110-220 A.C. motor to a 110 A.C. line
(Courtesy of: Century Electric Company)

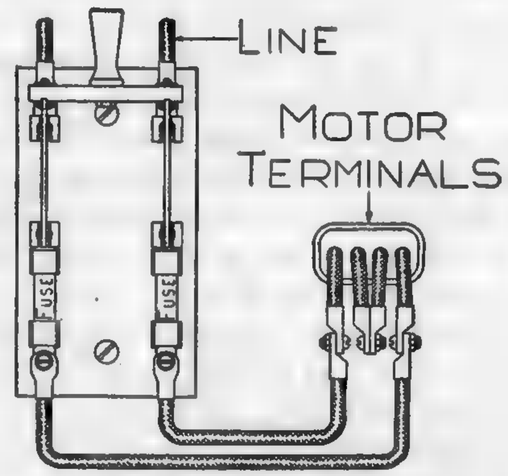


Fig. 124. The method of wiring a 110-220 A.C. motor to a 220 A.C. line
(Courtesy of: Century Electric Company)

terminals. Number 14 wire is of sufficient size to use with motors up to ¼ H.P.

Example. A 110-volt motor supplied with current at 95 volts will develop only about 75 per cent as much power as it would if supplied with current at 110 volts.

Figures 123 and 124 show the most common connections for single phase motors. Special motors requiring other connections are shipped with diagrams and instructions showing proper connections.

Figure 123. A 110/220 volt motor is connected to a 110-volt line through an across-the-line starter. The same connections are used to connect a 110/220 volt motor to a 110-volt line, etc.

Figure 124. A 110/220 volt motor is connected to a 220-volt line through an across-the-line starter. The same connections are used to connect a 100/200 volt motor to a 200-volt line, etc.

117. FUSES:

Where a motor is started and stopped automatically and is installed in an out-of-the-way place or controlled from a distance, the use of a fuse having a rated capacity of not more than 100 per cent to 110 per cent of the rated ampere capacity of the motor is recommended. This fuse is of ample size to enable a motor fully loaded under normal conditions to attain its rated speed.

To permit the motor to develop its maximum rated capacity for short periods, and to enable it to start quickly under a heavy or inertia load, when the motor is being started and operated under the direct supervision of an attendant, a fuse may be used having a rated capacity of 125 per cent, but in no case larger than 150 per cent of the rated full load current of the motor.

The above applies to plug and cartridge type fuses approved by the National Board of Fire Underwriters. Experience shows that link and wire fuses quite often are unreliable.

In Chapter VII is described a recent overload cut-out device consisting of a heating coil and ratchet throw-out arrangement built into the thermostat. A plug fuse will not protect an overloaded motor adequately because the fuse must be of enough capacity to withstand the starting load of the motor and this load is enough to burn out the motor if consumed continuously.

118. CLEANING:

Treat a motor as you would any other high grade apparatus. Dirt should not be allowed to accumulate in the motor. Compressed air or a hand-bellows should be used frequently to blow all the dirt out of the motor. Any oil which may overflow from the bearings should be wiped from the motor. A little attention in this regard will result in continued satisfactory operating results and enable the motor to give the best service for many years.

119. COMMUTATOR:

If the commutator becomes rough and burned, it should be cleaned by holding a piece of coarse (No. 1½ or 2) sandpaper against it with a flat block of wood, so that the insulation between the commutator bars may be cut down to a level with the bars. *(Never use emery cloth or emery paper on any commutator or brushes.)*

Emery cloth must not be used, as the abrasive on the cloth is often a conductor; if it collects between the commutator bars, it may cause them to short circuit.

120. BRUSHES—BRUSH-HOLDERS:

The brushes should move freely, but still fit closely enough to make good contact with the holders. If they do not

move freely, they will not make good contact with the commutator during the period of starting. If the brushes stick in the brush-holders, it is usually due to an accumulation of dirt and oil. Figure 125.

The brushes and brush-holders should be inspected occasionally to see that the brushes have not worn down to the point where they are so short that the brush-holder springs cannot press the brushes against the commutator. Brushes should all be of the same length. The brush-holder should clear the commutator at least 1/8 inch.

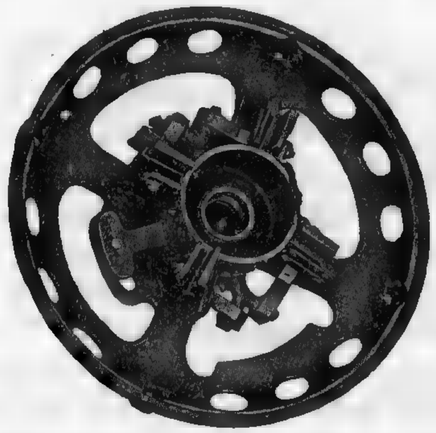


Fig. 125. A typical brush holder mechanism
(Courtesy of: Century Electric Company)

121. HORSEPOWER CAPACITY:

The motor will carry a greater load when running than it will bring up to speed at starting. However, such loads should not be imposed, since they may cause the motor to be pulled out of step with the line, causing it to slow down and start again. Such action results in making and breaking the electric circuit in the armature. This causes burning and pitting and produces poor contact, which reduces the horsepower capacity.

If the motor is pulled out of step with the line, it is an indication to the operator that an abnormal overload has been applied, which should prompt him to relieve the motor of the overload. It is not good practice to overload a motor continually, since motors are usually designed to give the maximum efficiency at full load. A motor out of step with the line will emit a regular beat in addition to the usual hum.

122. THE ADJUSTMENTS OF REPULSION-START INDUCTION SINGLE PHASE MOTORS:

In the great majority of cases where the action of a motor seems to indicate that there is something wrong with it, the actual trouble lies outside of the motor. Therefore, one should be prompted to inspect carefully the refrigerator machinery that the motor is driving to see that it is not imposing an overload upon the motor, due to the amount of work which the machine is doing, or due to having developed an unusual friction load in such machinery.

If the motor is belted to the compressor, see that there is sufficient oil in the bearings, that the shaft turns easily, that the shafting is in alignment, and that the belting is not too tight, etc.

123. REPULSION-START INDUCTION MOTOR TROUBLES:

1st. See that the commutator is in good condition. Frequent starting, improper fitting of brushes, low voltage, or possibly some other reason will cause the motor to run on the brushes excessively which will roughen the commutator. To correct this it is necessary to sand the commutator with coarse sandpaper (No. 1½ or No. 2) so as to clean it and keep the insulation level with the commutator bars. Use a block of wood to hold the sandpaper so that the high spots

may be cut down to a level with the low ones. (Do not use emery cloth or emery paper to clean the commutator.) When the commutator is badly burnt, the armature should be removed and placed in a lathe, where a slight cut should be taken off the commutator.

2nd. The brushes should fit well in the brush-holders, but still be free enough to allow the springs to press them firmly against the commutator. Also see that they have a good bearing fit against the commutator.

3rd. Be certain that the brushes are long enough. It may be that they have worn down so that the springs cannot force them to make good contact with the commutator.

4th. Examine the setting of the brush-holder. The pointer on the index washer should be set exactly at one of the running marks on the index plate on the commutator end of the motor. The upper running mark will give right-hand (clockwise) rotation and the lower running mark will give left-hand (contra-clockwise) rotation facing the commutator end of the motor.

After the governor has acted and the motor is carrying its load, the spring barrel ring should enter the bore of the brush-holder far enough so that the parallel motion fingers which are fastened to the brush-holder will rest on the outside of that ring. The brush-holder should not be closer to the commutator than $\frac{1}{8}$ inch.

Examine the brush-holder and spring barrel to see that the spring barrel ring does not stick in the brush-holder. This would prevent the brushes from dropping back on the commutator when the motor stops.

5th. Note how the motor is connected, whether for 110 or 220 volts, and see that it corresponds to the voltage of the circuit to which the motor is connected. Be certain the voltage is up to normal at the motor terminals all the time that the motor is starting and carrying its load.

6th. Examine the governor mechanism. It may not operate satisfactorily, due to the mechanism becoming clogged with dirt. An occasional drop of oil on the governor mechanism bearing points will do no harm. Figure 126.

The motor winding should be cleaned occasionally so that the dirt accumulated will not weaken or rot the insulation.

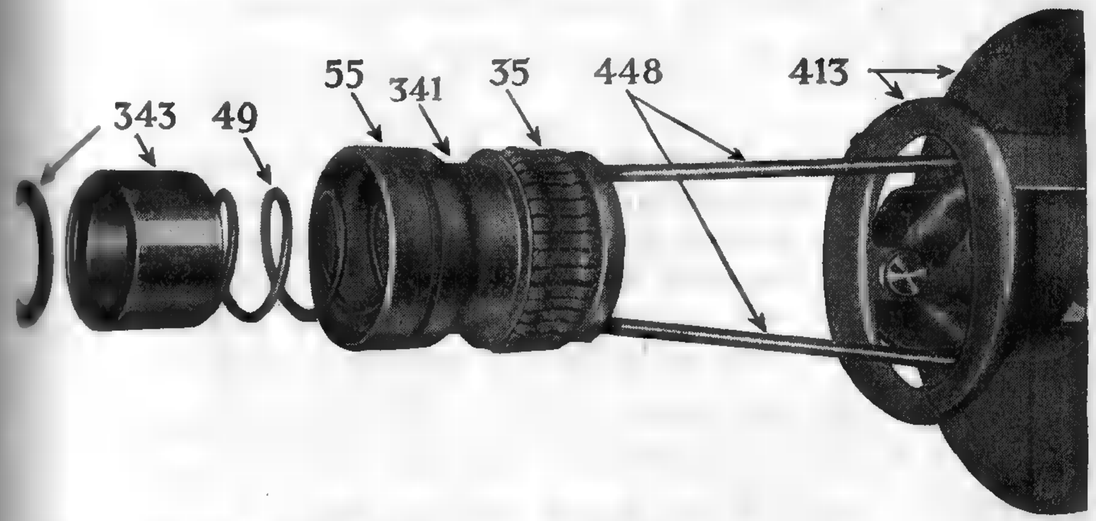


Fig. 126. The governor mechanism which changes the repulsion-start motor into a single induction motor after gaining full speed
(Courtesy of: Century Electric Company)

Storage of the motor in a damp place for some time may cause a sufficient amount of rust to accumulate preventing the governor's satisfactory operation.

7th. Examine the short circuiting device. The short circuiting segments must make good contact between the commutator bars and the copper short circuiting ring; therefore it may be necessary occasionally to clean the inside of the commutator. There will be no occasion for trouble at this

point except for an abnormal accumulation of dirt or frequent imposition of loads in excess of the maximum capacity of the motor.

8th. Test for short circuits in the armature. This may be done as follows:

1. Disconnect the motor from the apparatus it is driving.

2. Raise all the brushes off the commutator.

3. Close the switch which is used to start the motor.

4. Turn the armature slowly by hand. If there are any short circuits in the armature, the armature will apparently stick opposite each pole. The tendency to stick will be quite pronounced and armature will turn with a decided jump. If the armature turns freely, then the winding is all right.

9th. Test for short circuits in the field winding. This may be done as follows:

1. Raise the brushes off the commutator.

2. Close the switch, thus throwing the field winding across the line. Leave the switch closed for a few minutes.

3. If there is a shorted coil there will be an unusual heating in this coil.

10th. Examine the bearings to see if they are worn. If the armature is striking the iron of the field, this is a sure indication that the bearings are worn out and must be replaced. As the clearance between the armature and field varies from .015 inch to .030 inch, dependent upon the size

of the motor, a bearing should be replaced which shows any appreciable sign of wear. A heavy rumbling sound at the time of starting usually indicates that the bearing is badly worn, although the armature does not quite touch the field.

The bearings are most commonly made of phosphor bronze and are pressed into the end brackets. Occasionally these bearings are locked in by a pin pressed through the bearing housing and into the bearing. The bearing must always be pressed inward to remove it. One must be careful not to put an angular load on the housing when pressing the bearings out as this will probably crack the housing. After the bearing is pressed into the bracket when installing a new one, the bearing must be reamed. It is best to ream the two in line with adjustable reamers. The surface of the shaft in contact with the bearing must be perfectly smooth. A scored shaft may be repaired in a lathe with the use of a grinder in the tool post.

11th. Hot bearings. The bearing on the commutator end of all motors will show a normal temperature rise in excess of the bearing on the pulley end, because of a lesser forced circulation of air around it. However, the temperature rise should not exceed 40°C. or 72°F. above the surrounding atmosphere. Any one of the following causes may result in a hot bearing:

1. Oil which is too heavy.

2. Oil which is too thin. (Select a good grade of mineral lubricating oil which is not greatly affected by a change in temperature and does not foam or bubble too freely.)

3. Dirt or grit in the oil.

4. The belt may be too tight

5. The pulley hub may be rubbing against the bearing.

6. The motor may not be properly lined up, causing the armature shaft shoulder to pull or be pushed against one bearing.

7. The shaft may be sprung.

124. FAILURE OF GOVERNOR TO ACT AND TAKE THE TENSION OFF THE BRUSHES:

This would indicate that one of the following is the cause:

1st. Low voltage. The voltage at the motor terminals must not be lower at any time than that for which the motor is wound, if the motor is expected to develop its rated capacity. (The power an alternating current motor will develop varies directly as the square of the impressed voltage.)

2nd. Overload. Frequently in cold weather poor oil will be so nearly frozen in line shafts or other bearings as to cause a heavy friction load.

3rd. Frequency different from that for which the governor spring tension is adjusted. (Remember the frequency of the circuit governs the speed of any A. C. induction motor.) Occasionally current that is supposed to be exactly 60 cycles, or some other particular frequency, is found sufficiently higher or lower than what it should be to make a variation of as much as 5 to 10 per cent in motor speed.

If the motor is disconnected from the apparatus it is driving, and the governor acts properly after closing the switch, then "1", "2", and "3" is the probable cause of its failure to act when connected to its load.

Close the switch and note whether the speed of the motor decreases after the governor has acted; if it does, then loosen the spring barrel nut one, two, or more turns as necessary.

If that is regulated and if during the time the motor is starting the voltage is maintained at 110 or 220 volts at the motor terminals (according to the connections), its failure to act is probably an overload; however, as a trial the spring barrel nut may be loosened one or two turns, returning it to its original position if it does not produce the desired results. This nut can be reached by removing the end bracket from the commutator end of the motor, where the nut will be found on the armature shaft. It has a lock spring to prevent it from turning.

Failure of the governor to act, under a load within the rated capacity of the motor, with proper voltage at the terminals all the time the motor is being started, indicates that the frequency of the circuit is lower than that for which the governor is adjusted. It is therefore necessary to loosen the governor spring one or more turns. After the governor spring nut has been loosened and the governor operates, if the motor does not hold its speed but drops back, then the motor is overloaded or the voltage is low.

In some small motors, adjustment is not necessary; so on these a non-adjustable spring collar is used instead of an adjustable spring barrel nut.

When removing an end bracket, mark it with a file or punch and also the body of the motor (stator) to enable one to assemble it in the correct order.

125. INSTALLING A NEW ARMATURE OR REWOUND ARMATURE:

Whenever a new armature or a rewound armature is installed in a motor, it is always necessary to check the running marks as slight variations in the windings make large changes in the position of the running marks. This check may be done as follows:

1. Loosen the screw in the index washer.

2. Turn the brush-holder until the point on the index washer is half-way between the original running marks (this point is called the dead point) and tighten the screw on the index washer.

3. Turn on the switch. (If the index washer is set correctly on the dead point the motor will not start in either direction.)

4. If the motor starts in either direction, open the switch, move the index washer in a direction opposite to the direction in which the armature turned, tighten the screw on the index washer, and try it again.

5. When the true dead point (the point at which the motor will not start in either direction) is found, mark it with a pencil or a piece of chalk.

6. The new running marks should then be marked on the index plate in such a position that they are the same distance apart as the original running marks and the new dead point is exactly half-way between them.

7. Set the point on the index washer exactly on one of the new running marks.

126. FREQUENT ACTING OF THE GOVERNOR:

This would indicate one of the following causes:

1st. The most probable cause is that the tension of the governor spring is not correct for the frequency of the circuit on which the motor is installed; hence the motor is unable to reach such a speed before the governor acts as will allow it to bring its load up to full speed (which is governed by the frequency of the circuit) after the governor has acted. This trouble may or may not be accompanied by blowing of

the fuses. Provided the proper voltage is maintained at the motor terminals all the time the motor is starting, the remedy is to tighten the governor spring nut one or more turns as may be necessary. This nut can be reached by removing the end bracket from the commutator end of the motor, where the nut will be found on the armature shaft. It has a lock spring in it to prevent it from turning.

2nd. Change of frequency may be caused by change of generators, or by poor regulation of engine or turbine. It is not infrequent that the current is supposed to be exactly 60 cycle, or some other particular frequency, when on investigation it is found that the speed of the generator is sufficiently higher or lower than what it should be to give that frequency, to make a variation of 5 to 10 per cent.

3rd. Change of voltage at the motor terminals.

1. Sudden change of load on generator.

2. Frequent starting of large motors on the transmission line.

3. Heavy varying load on motors on same circuit.

4th. Low voltage. Causes:

1. Wire which is too small.

2. Transformer which is too small or has poor regulation with an induction load.

3. Loose connection, either at the motor terminals or at the switch, or in the line.

5th. Overload.

6th. Poor contact between short-circuiting segments and commutator bars, resulting from an unusual accumulation of dirt.

127. TEMPERATURE:

Do not use the hand to judge the temperature of a motor. Use a thermometer and check against the allowable temperature rise shown on the name plate.

The temperature of the motor should not rise more than 40°C. (72°F.) over the room temperature. This means an average maximum temperature of approximately 150°F.

128. CAPACITATOR TYPE REFRIGERATOR MOTOR:

Recently, domestic refrigerators have been using a different type of motor than the repulsion-start induction motor;

Fig. 127. A full capacitator type refrigeration motor
(Courtesy of: Wagner Electric Corporation)

since 1933 models this new type of electric motor has become very popular. This type is called the capacitator type and the name is derived from the use of a capacitator or of a condenser and a transformer. Figure 127. It becomes a two-phase motor when starting and reverts to single phase when it has gained 75 per cent of its full speed. The capacitator is used to change the phase angle of the current in the starting winding to produce two-phase electrical characteristics when starting.

The mechanical construction of the motor is quite similar to the induction motor; that is, the external appearance, the mountings, and the bearing design is in the conventional

manner both as to size and lubrication. However, instead of using a starting winding in the armature, the capacitator type has a condenser and a transformer mounted on top of

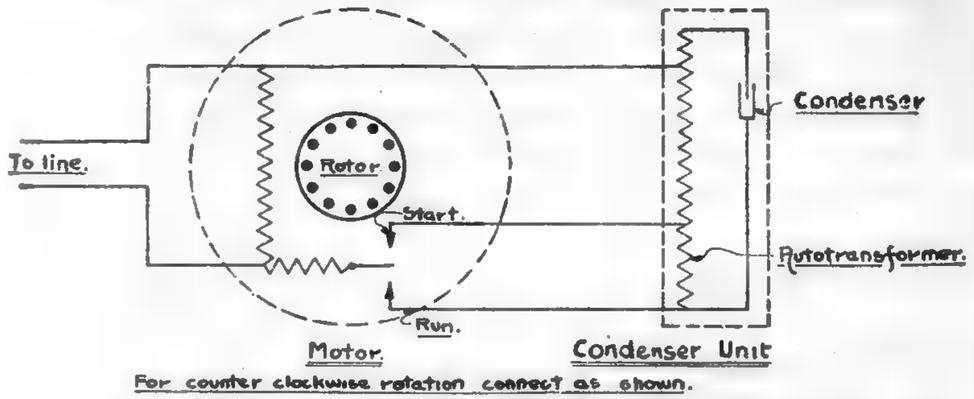


Fig. 128. The wiring diagram of a full capacitator motor
(Courtesy of: Norge Corporation)

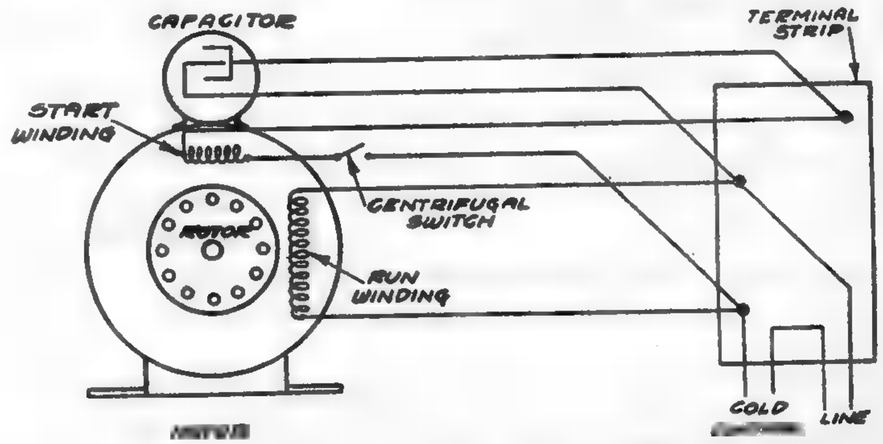


Fig. 129. Electrolytic capacitator start-induction run motor
(Courtesy of: Stewart-Warner Corporation)

the motor which is connected to a centrifugal switch built into the motor. Figure 128.

The operation of the mechanism is quite simple. When the motor starts, the centrifugal switch is closed, making the current pass through both the starting winding and the run-

ning winding. The starting winding is connected in series with a capacitator which puts the electrical surges out of step with those of the running winding. This produces a temporary two-phase motor and gives a very high starting torque. When the motor reaches approximately 75 per cent of its rated speed (1200 R.P.M.) the centrifugal switch opens disconnecting the starting winding. The motor, however continues to run, but now as an induction motor. These motors are commonly called capacitator-start induction run

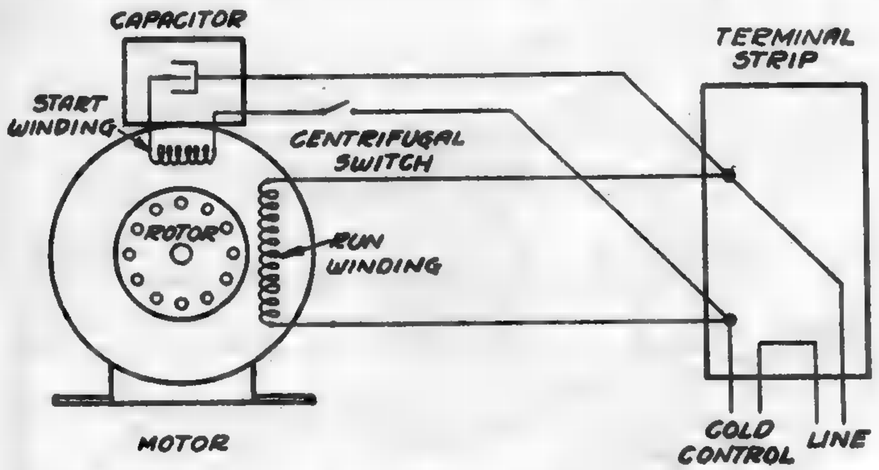


Fig. 130. Permalytic capacitator start-induction run motor
(Courtesy of: Stewart-Warner Corporation)

motors. Two of these motors with some variations in design are shown in Figures 129 and 130. A full capacitator type motor differs from the above in that a transformer is used in addition to the capacitator.

129. CAPACITATOR TYPE MOTOR TROUBLES:

The troubles encountered in the capacitator type motor are very few and they deal mainly with the mechanical condition of the motor, outside of the two electrical troubles encountered in electric motors. These two troubles are: there is a possibility that the centrifugal switch used for connecting and disconnecting the condenser may become worn, in which case a replacement is necessary; also an open or short circuit may occur in the field windings, in the condenser, or in the auto transformer. The latter ones naturally necessitate a replacement of the motor while the first trouble may be repaired by installing a new switch. The mechanical troubles are practically identical to those encountered in the repulsion-start induction motor, involving bearing wear, end play, excessive vibration, orientation of the motor to the compressor, and the air gap between the rotor and stator.

130 INDUCTION MOTORS:

Induction motors are motors having no windings on the armature. One or more field windings are placed on the stator and the alternating current passing through these induces a magnetic field; this in turn passes through the armature inducing an electrical current and a field in it so that it revolves as it attempts to keep up with the changing field polarities. To start these motors in the same direction each time, an exciter, or off-center field pole is put in the motor, and a centrifugally operated switch allows the current to go through this coil only when the motor is stopped or running slowly. Induction motors placed inside the hermetic machines use two field windings: (1) a starting winding, (2) a running winding. An external relay is used to change from the starting to the running winding as soon as the motor reaches approximately 75 per cent of its full speed.

131. DIRECT CURRENT MOTORS:

Certain localities using D. C. power must have direct current motors for their refrigerators. These motors are compound

wound and are constructed mechanically very similar to both the capacitator and repulsion-start induction type. Figure 131. The possibilities for wear are a little greater in the direct current motors than in the others because of the armature design. This design necessitates constant contact of the brushes against the commutator, giving rise to the following possible troubles: dirty commutator, worn brushes, high

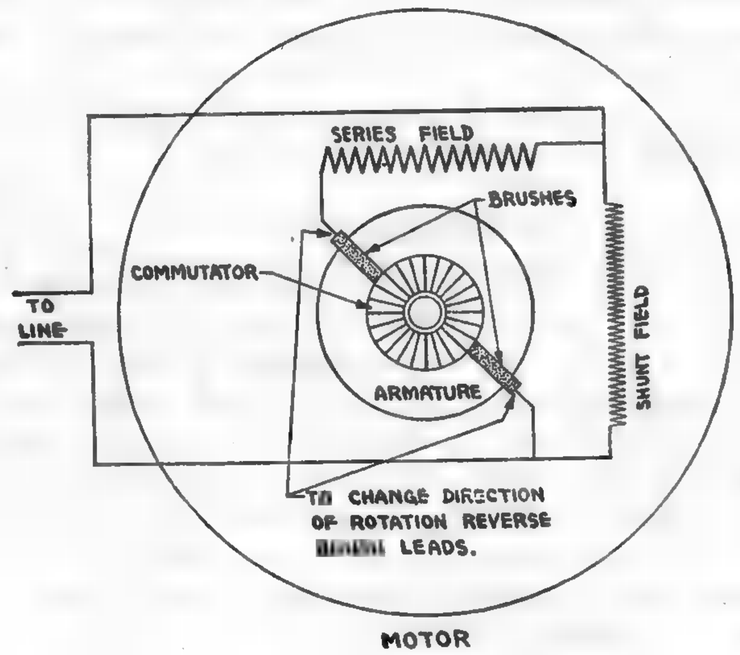


Fig. 131. Wiring diagram of a compound direct current refrigerator motor
(Courtesy of: Norge Corporation)

mica, shorted armature, squeaky brushes, etc. In general, all of the brush and commutator troubles are treated as in the case of the repulsion-start induction motor.

132. RADIO INTERFERENCE:

Most refrigerators will give a slight amount of radio interference in the average installation. This will usually amount

to a slight snap in the radio at the instant the refrigerator stops, and should not be more noticeable than the turning off of a light. This may be eliminated some by grounding the frame of the motor to a water pipe or by placing a condenser between the frame of the motor and a convenient ground. In general, the normal interference is not disagreeable and need not be given any attention.

Excessive radio interference of a continuing nature when the refrigerator motor operates or when it starts, indicates a loose electrical connection or some fault in the motor's starter mechanism such as worn brushes, badly pitted commutator, or loose connections. The particular trouble can be easily determined by a careful examination of the motor.

Occasionally a static charge will be built up on the belt of a belt-driven compressor. The discharge of this charge will cause radio interference. If the motor and compressor are grounded together, this annoyance will be eliminated.

133. STANDARD MOTOR DATA:

The split phase motor involving the repulsion-start induction type and the capacitator type is obtainable in 25, 30, 40, 50, and 60 cycles and uses either 110 or 220 volts. The 30 and 60 cycle motors run at 1750 R. P. M. while the 25 and 50 cycle motors have a speed of 1425 R. P. M. The 40 cycle runs at a speed of 1150 R. P. M. The D. C. motor voltages are 32, 115, and 230 volts and run at a speed of 1725 R. P. M. These motors are supposed to run continuously with a temperature rise not exceeding 40-55°C. which is approximately 90°F. The fuses for the capacitator and the repulsion-start induction motors are the same, but they are larger than those used for direct current motors. Paragraph 443.

134. GAS SUPPLY:

The two fuels used for the absorption system refrigerators are kerosene and city or illuminating gas, although electrical heating elements are sometimes used. The kerosene that may be used is the standard grade used at present for lamps, heating, etc., and must have a heating value of about 19,000 B. T. U. per pound. It must be clean fuel in order to prevent a pollution of the burner or a sediment deposit on the burners. The cleaner the fuel the less frequently the burners have to be cleaned. It is very important to keep the kerosene heaters in a level position to obtain the greatest efficiency from them.

The gas-fired refrigerators should be supplied with gas under a 2 to 3 inch water column pressure and should have a heating value of approximately 540 B. T. U. per cubic foot. The gas must be strained before being admitted to the burners and must also have a pressure regulator to insure an unvarying pressure on the burner. It is good practice to become acquainted with the local rules on installation of these refrigerators before attempting to install them.

In communities having natural gas, a different burner is required than when manufactured gas is used.

In all cases of burner difficulty, a check should be made to determine that the burner being used is the correct one for the gas used.

135. REVIEW QUESTIONS:

The answers to the following questions may be found on page 813.

1. List the types of motors used in domestic refrigeration.
2. How many field windings are used in 110-220 volt repulsion-start induction motors?

3. Why must a motor be cleaned regularly?
4. Do all repulsion-start induction motors have brush-lifting mechanisms?
5. What is the purpose of short-circuiting the commutator of a repulsion-start induction motor?
6. Explain the two types of commutators.
7. Why is not emery cloth recommended for commutators?
8. Why is a plug fuse inadequate protection for a motor?
9. What advantage does a capacitator motor have over a repulsion-start induction motor?
10. Why is it essential to keep the burners clean and dry in kerosene and gas-fired refrigerators?
11. How often should motor bearings be oiled?
12. Why do some motors have rubber or spring mountings?
13. What kind of electric motors are usually used in hermetic refrigerators?
14. What are the common voltages used on direct current motors?
15. How can radio interference caused by the refrigerator motor be reduced?

CHAPTER IX

DOMESTIC REFRIGERATOR CABINETS

The common use of the ice-box has shown the advantages of the well-insulated cabinet. In the development of the ice-box various insulating materials have been used and some have been found to be better than others. In the electric refrigerator, due to the fact that the cost of refrigeration is largely the cost of pumping out heat that leaks into the box, the matter of insulation becomes a very important one. Tests have shown that the greatest heat transfer to the refrigerator is through the insulation.

136. INSULATION:

In referring to Chapter I, Paragraph 22, it was learned that there are three ways in which heat may be conveyed from one point to another. Care must be taken in the design of the refrigerator cabinet that heat is held from being transferred into the cabinet by either of these three methods. Heat is held from leaking through the cabinet by lining it with two or three inches of some heat insulating substance such as cork, wood fibre, aluminum foil, or other insulating material. The old domestic cabinets used slab cork as the insulation and this was faced by cabinet wood. More recent cabinets, having steel walls, use various insulations. The cabinets are constructed with metal or wood frames and have solid steel inner and outer shells. The insulation is inserted between the two surfaces in a slab or package form. Figure 132. The greatest insulation problem is moisture. Many insulations are made with equal insulating powers when new, but as they age, many of them become moisture-laden and lose all their insulating ability. To prevent this, all the insulations are

sealed water-tight before and after putting them in the cabinet. The problem is to prevent air from coming in contact with the cold insulation or inner surface and causing condensation there. If this moisture does collect, it will eventually ruin the cabinet. Manufacturers seal the insulation with hydrolene (a petroleum by-product) which is an

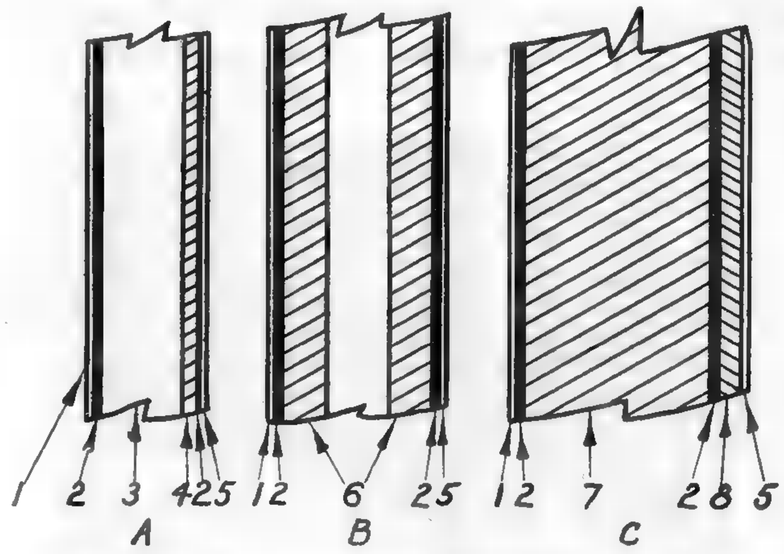


Fig. 132. Three different refrigerator wall constructions
A. Older type: B. Modern ice box; C. The usual electric refrigerator box insulation

1. Inner lining usually steel with porcelain finish; 2. Cardboard backing or a coating of odorless asphaltum; 3. Dead air space; 4. Hair felt or equal; 5. Exterior of steel usually lacquered; 6. Cork or hair felt; 7. Slab insulation wrapped in water-proof paper; 8. Veneer or paper backing

odorless tar. After the insulation is in place, all the crevices are filled with the same material. The insulation thickness varies from 2 to 4 inches with 3 inches being a good value. To prevent heat transfer by convection, such as would occur if air were allowed to circulate in and out of the cabinet, the door joints and other openings to the box are carefully

sealed either with rubber seals, such as door seals, or with sponge rubber in such places where tubing and other lines are led into the cabinet. Figure 133. Radiation of heat into the box is lessened to some extent by coating the outside and the inside lining of the cabinet with materials that do not readily absorb or radiate heat. The porcelain surface seems to be quite satisfactory from both of these standpoints. White enamel lacquer also is satisfactory.

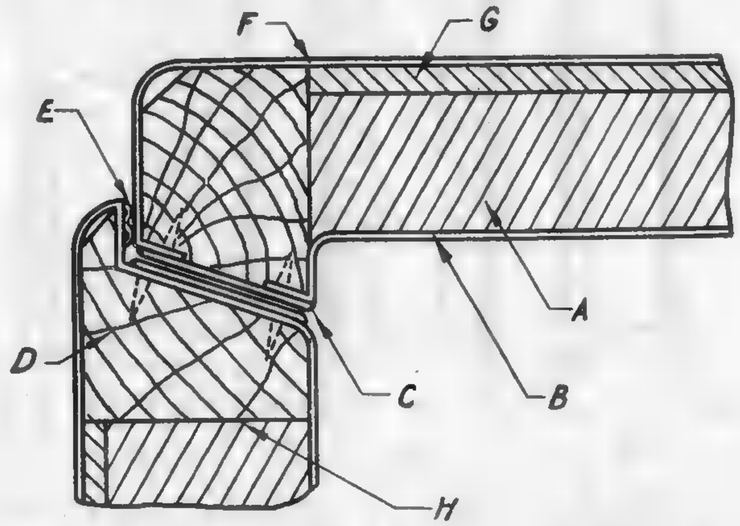


Fig. 133. A cross-section of a refrigerator door joint construction
A. Slab insulation; B. Inner steel lining porcelain covered C. Breaker strip; D. Wood door frame; E. Door gasket; F. Exterior steel lacquer finish; G. Cardboard backing for outside shell; H. Surfaces well covered with a water-proof coating

A comparatively new development in insulation consists of successive thin metal sheets placed ¼ inch to ¾ inch apart. Metals to be used for this purpose must not corrode readily, must have structural strength, and must reflect heat well. Steel, zinc, lead, copper, tin, aluminum, as well as a number of alloys, fill these requirements if processed correctly.

Ferro-Therm, which is a trade-marked and patented steel sheet product, is an example of metal sheet insulation. It utilizes sealed air spaces of varying thickness and arrangement, and is of carefully pre-formed shape to attain this full insulating efficiency.

The exceptional degree of reflectivity of heat possessed by dull metal surfaces reduces the radiation through the alternate layers of air and metal, and the narrow air spaces decrease convection and conduction.

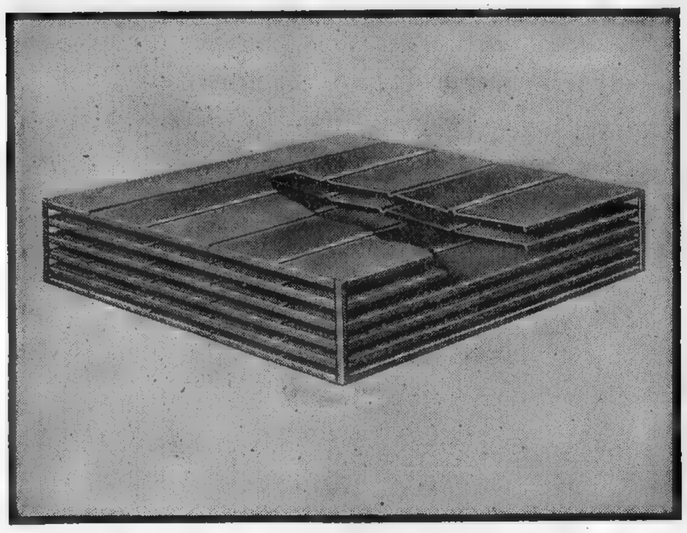


Fig. 134. A section of six layer metal insulation
(Courtesy of: Ferro-Therm Corporation)

This type of insulation may be used in any kind of service at almost any temperature: in refrigerators at low temperatures, in residences at ordinary temperatures, and in manufacturing processes at high temperatures. It is claimed that less wall thickness is required for an equal insulating value of metal insulation than with the usual materials used for these purposes. Figure 134 illustrates a section of metal insulation using six layers. See Chapter XVII for tables giving

the insulation value of materials commonly used in refrigeration insulation.

137. CLASSIFICATION OF CABINETS:

Manufacturers have two popular ways of classifying cabinet styles and sizes. One way is by the door design which may be a single door, double door, or multiple door. In any case, the cabinet is usually specified as to the content capacity in cubic feet. This usually varies from the smallest of about 4 cubic feet up to the large commercial size. In the very large cabinets, the number of doors usually increases with the capacity of the unit.

The size of the cabinet may be classified in two ways: in either gross cubic feet, or net cubic feet. The gross cubic contents are measured by multiplying the three interior dimensions together. The net cubic feet (usable cubic feet) is this volume less the space occupied by the cooling unit. This latter volume is usually the one used when comparing cabinets.

138. LOCATION OF CONDENSING AND COOLING UNITS:

Manufacturers differ as to the location of the condensing unit in self-contained cabinets. There seem to be definite reasons for the positions that the condensing units occupy in the cabinet. Manufacturers placing the condensing unit in the bottom of the cabinet claim that the condensing unit is more efficient because it is in the coolest part of the room. Also, that the shelves of the cabinet are more convenient being on a higher level and within the housewife's ready reach. Manufacturers who place the condensing unit at the top of the cabinet claim that this arrangement makes the cabinet more efficient because the heat radiated from the condensing unit does not have to travel past the refrigerated

portion of the cabinet; therefore less heat will be transferred from the condensing unit back into the cabinet. In some cabinets the condensing unit and the cooling unit are combined as a single unit that sits on the top of the cabinet. Figure 135. This makes for considerable simplicity in assembly and, perhaps, in servicing of the unit, particularly if the unit has to be removed from the cabinet for service purposes.

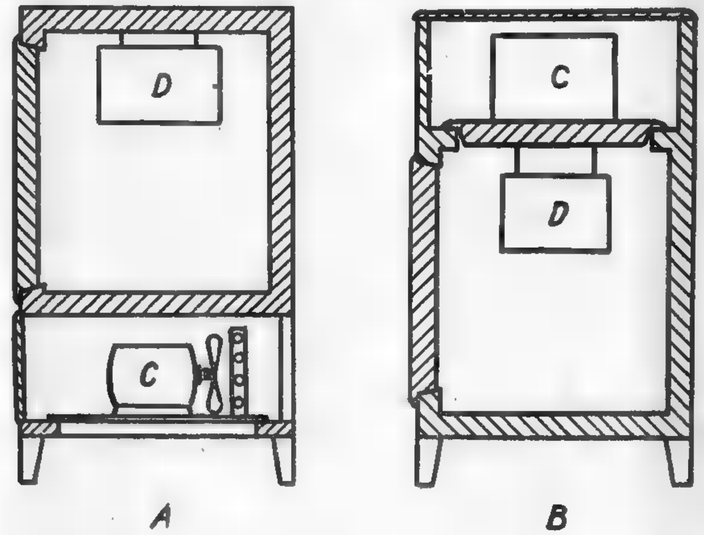


Fig. 135. Cabinet designs
A. Conventional; B. Package; C. Condensing or machine unit; D. Cooling unit

From the standpoint of the efficiency of a refrigeration unit it will probably be best to remove the condensing unit from the cabinet entirely and either place it in the basement or in some place that is normally at a cooler temperature than the kitchen. One manufacturer goes to the extent of placing the condensing unit in the basement at no extra charge because it is realized that extra satisfaction will be received by the owner from this type of installation. The

opinion is generally conceded that the purchaser of a cabinet is more interested in the convenience of the cabinet and the convenient elevation of the shelves than in the very small

Fig. 136. A cabinet with the condensing unit located in the base
(Courtesy of: Fairbanks-Morse Corporation)

increase in efficiency that may be obtained by any particular location of the condensing unit. Figures 136 and 137 illustrate two popular cabinet designs.

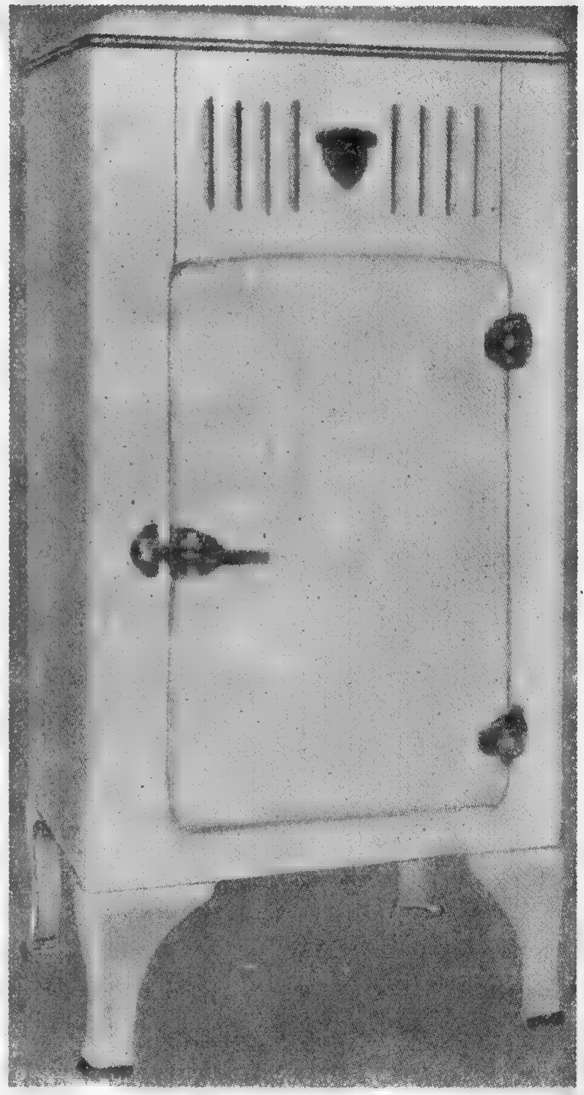


Fig. 137. A cabinet with the condensing unit located in the top
(Courtesy of: The Crosley Radio Corporation)

In some of the absorption type machines a few of the mechanisms of the refrigerator are located on the side of the cabinet due to the ease with which this mechanical arrangement may be connected with the cooling unit in the cabinet. In the more or less conventional compressor condensing type, the cooling unit is generally placed in the

Fig. 138. A Crosley "Shelvador"
(Courtesy of: The Crosley Radio Corporation)

upper left hand corner of the cabinet, although a few manufacturers still place the cooling unit in the upper right-hand corner of the cabinet. At any event, the cooling unit should be placed at the top in order to provide for the best refrigeration of the air and consequently for the interior of the cabinet and its contents.

Some manufacturers are now placing the cooling unit in the top center of the cabinet, while one company has it built in a form of a shelf across the top of the cabinet.

139. REFINEMENTS IN DESIGN:

Some manufacturers place an electric light in the box and connect it with a switch in such a manner that when the cabinet door is opened a light in the interior of the cabinet is turned on. This assists in selecting articles from the cabinet, particularly if it is located in a dark corner of the room. Most manufacturers place a unique locking device on the door so that some little pressure is applied to the door causing it to be sealed at all times in order that the air leakage past the door may be minimized as much as possible. A few cabinets are designed in such a way that a floor pedal operates the door latch.

Crosley produces a "Shelvador" arrangement which consists of a wire holder, for small articles, built into the refrigerator door. Figure 138. The Fairbanks-Morse cabinet has an inner metal door, with a wire holder for small articles attached to the outside of it. This aims to conserve refrigeration by making it unnecessary to open the inner door to obtain many necessary articles from the refrigerator. Figure 139. The Westinghouse cabinets for 1935 have a revolving shelf held up by a very substantial beam, mounted on the back wall of the cabinet interior. Hydrators, vegetable bins, ice tray releases, and other methods for facilitating the use of the refrigerator have been introduced. Recent cabinets have been constructed with styling as the paramount object; modernistic designs are very common, using black and white porcelain. The hinges are concealed and the door

Fig. 139. A Fairbanks-Morse "Conservador"
(Courtesy of: Fairbanks-Morse Corporation)

latches are designed to operate more easily. Figures 140 and 141 illustrate devices which assist in removing ice cubes.

140. CARE OF THE REFRIGERATOR:

In the operation of any domestic refrigerator, the owner should be instructed not to allow the door to remain open.

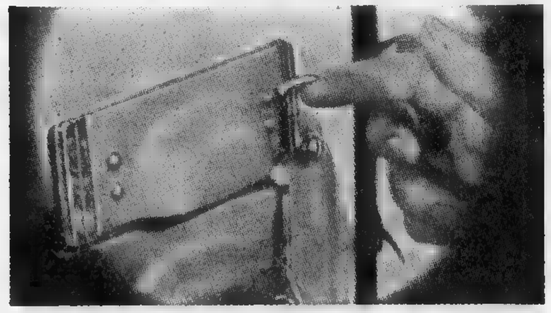


Fig. 140. An ice cube tray release lever
(Courtesy of: Electrolux Refrigerator Sales, Inc.)

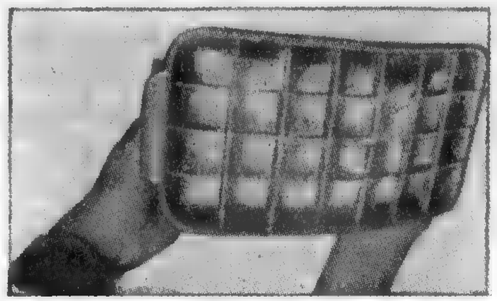


Fig. 141. A rubber ice tray
(Courtesy of: The Dayton Rubber Company)

Due to the very great difference in temperature between the inside of the cabinet and the outside room temperature, convection currents will be set up as soon as the door is opened. This will bring a great deal of heat into the cabinet; therefore, the door should be open only when removing articles from or placing articles in the box.

Another point in the operation of a refrigerator that is often neglected is the matter of defrosting the cooling unit. The housewife particularly fails to appreciate the fact that if the cooling unit is covered with frost and ice it is not efficient. She may even feel that the frost and ice on the unit indicate that it is operating better than it would if this accumulation were not there. This, however, is not the case. The frost and ice act to some extent as an insulator, keeping the air from flowing into the cooling unit and resulting in a higher box temperature; consequently more running or operation of the condensing unit is required in order to maintain the proper box temperature. In general, the unit should be defrosted once a week. A defrosting more often may be necessary if uncovered liquids or other moist foods are placed in the cabinet in large quantities. Most manufacturers place a defrosting switch in or near the control panel which makes it more easy for the housewife to defrost the refrigerator at regular intervals. A tray or pan of some kind should be placed below the cooling unit before the unit is defrosted; otherwise the water that is formed in defrosting the unit will drip on articles below it and on the bottom of the cabinet. Paragraph 146.

141. CLEANING REFRIGERATORS:

Refrigerator boxes are finished with either a porcelain or a special lacquer coating, and the cleaning of the refrigerator finish depends upon which of these two materials has been used. If the finish is porcelain, one must be very careful of it because of the brittleness of the glass-like finish.

To clean porcelain the same substances may be used as for cleaning glass, such as borax or any good compound which will not scratch the surface and will not discolor it. It is imperative that for cleaning the inside of the cabinet

a cleanser be used which has no odor. After cleaning, a thorough rinsing is necessary. Occasionally the interior of the cabinet becomes stained with an iron stain on the porcelain due to cracks appearing in the porcelain or at the joints. This stain may usually be removed by a thorough cleaning, but if this is not satisfactory it may be covered over by using a correctly shaded lacquer.

One of the best solutions for cleaning the interior of a cabinet is baking soda dissolved in warm water. This solution cleans, deodorizes, and leaves no harmful residue.

142. PATCHING PORCELAIN:

When filling in cracks or chipped parts of a porcelain finish, a special porcelain patching material should be obtained. Because of the inherent nature of porcelain, its color shade will vary somewhat. A patching kit may be obtained with the several colors needed. If necessary, blue ink may be added to the patching material to obtain the right shade. In doing this work it is first necessary to clean the surface to be patched quite thoroughly, then apply the patching cement with a small hairbrush, being sure that the cement is not too thin. After the cement has been applied, it should be smoothed down with water sand paper and then polished with a soft piece of paper or cloth.

143. REPAIRING LACQUER FINISHES:

The lacquer finished cabinets, of course, may be repaired by spraying lacquer on the parts to be refinished. If the finish has broken through the base coating or primer coat, it will be necessary to reprime the surface before applying the enamel. It is also imperative here that the correct shades be used. White, however, is predominant. When retouching

lacquered surfaces, that is, applying some new lacquer, it is quite important that the surface to be refinished be absolutely clean, both the metal and the under coat of paint. The cleaning may be done by sand papering with a water sand paper until absolutely smooth and then cleaning with a carbon tetrachloride liquid and allowing the surface to dry. The surface should then be sprayed with a primer coating until all bare spots are covered by the primer coat. The primer should not be applied over any paint. Allow this primer coating to dry and then spray with the finishing lacquer, being very careful as to the thickness of the application which might result in a sag in the paint. At least two coats of finishing lacquer should be applied in order to obtain a nice finish. After the final coat has been applied it is sometimes convenient to spray the surface with some lacquer thinner, which blends the patching in with the original finish and also removes any rough spots.

144. CLEANING LACQUER FINISHES:

When cleaning the lacquer surfaces, great care must be taken to insure that the cleaning materials do not harm the surface. Very gritty cleaning materials should not be used as they will very readily scratch the surface and rubbing, if necessary at all, should be kept to a minimum. To clean lacquer finished cabinets, solutions and materials are now on the market which have the property of cleaning and polishing the surface simultaneously. These may be applied with a soft, wet cloth and then rinsed. It is recommended that the cabinet be cleaned rather frequently to eliminate any odor transfers from one food to another and from the cabinet to the food. The cleaning of the cabinet may be compared to cleaning and polishing an automobile. The process is the same.

145. CLEANING ICE TRAYS:

In certain localities where the water contains minerals and salts that have the property of discoloring aluminum or copper ice trays in the refrigerator, it is usually found that the ordinary cleaning powder and soaps do not have any effect on the stain. However, this stain may be removed quite easily by the following process: dip the trays in a hot solution of water and lye in the proportion of two gallons of water to a pound of lye, then rinse the trays in pure running water. Occasionally if this does not remove all the stain a small brush will facilitate the work. After rinsing the lye solution off the trays in the running water, it is necessary to dip the trays in a vinegar solution, which will neutralize the lye and prevent any further chemical action on the metal. Another rinsing and the trays are ready to be used again. The trays should be immersed in the lye and vinegar solutions for approximately ten minutes at a time. Never leave them there any longer than this period. Use a double immersion, if necessary, because if left in too long it is likely to remove the finish from the metal and spoil the appearance of the trays.

146. DEFROSTING THE COOLING UNIT:

There are two reasons for defrosting the cooling unit of the refrigerator. First, the coating of frost, collecting on the cooling unit tubes and surface acts as an insulator and prevents an easy transfer of heat from the box to the cooling unit. Second, this collection of frost on the cooling unit is usually odor-laden and will permeate the food with an unpleasant odor. Therefore, it is essential that this frost be removed if it accumulates to a thickness of $\frac{3}{8}$ inch; and regardless of the thickness of the frost, the unit should be defrosted and the moisture removed every two weeks at least.

Whenever the refrigerator has a defrosting switch all that is necessary is to shut down the unit over night. This minimizes the spoiling of the food in the cabinet during the defrosting period. In those refrigerators which are not equipped with a defrosting switch or in some gas-fired refrigerators, a very convenient method of removing all frost from the cooling unit is to fill the ice trays with very hot water and to repeat this until the frost has melted off the surface of the cooling unit.

Needless to say, a drip pan or a frost pan should be placed underneath the cooling unit during the defrosting process, or the cabinet will become flooded with water that drips from the unit. This tray is usually made of glass and the housewife will find it more convenient to remove the tray from the box except during the periods of defrosting because it facilitates the circulation of the cold air.

147. REVIEW QUESTIONS:

The answers to the following questions may be found on page 815.

1. Why are refrigerator cabinets insulated?
2. What is the average thickness of the insulation?
3. Why should the insulation be moisture proof?
4. What is meant by net contents of the cabinet?
5. What are the possible locations of the condensing unit?
6. Why are ice tray releasing mechanisms so necessary?
7. Why must a cooling coil be defrosted?
8. How thick may the frost become before it should be removed?
9. What is a good porcelain cleaner?
10. How may one clean discolored ice cube trays?
11. Name three substances used for insulation.

12. How are cabinet doors made air-tight?
13. Name the various cooling coil locations in the cabinet.
14. Why should the cooling coil always be located near the top of the cabinet?
15. Why should liquid and moist foods be covered when placed in the refrigerator?

CHAPTER X

DOMESTIC REFRIGERATOR INSTALLATIONS

The sale of a domestic refrigerator to the customer should not end the dealer's responsibility. It is equally important that the installation should be very carefully, accurately, and conscientiously made in order to keep the customer convinced that he has made a wise purchase.

148. GENERAL DIRECTIONS:

The economy and length of service rendered by the refrigerator is greatly dependent on the proper position of the box. It is of utmost importance that the box be placed in the coolest convenient place where there is no possible chance of its being too much in the sun's rays. Another precaution of paramount importance is the ventilation of the condensing or machine unit. If this unit is poorly cooled by improper air circulation it means an increase in the cost of running from 5 to 50 per cent. It also means a more rapid deterioration of the whole mechanism. To prevent this occurrence it is necessary to provide air vents. This means that the refrigerator must be provided with an air space around it. These ventilation rules (Figure 142) vary with particular makes, but by using the one fundamental of air circulation, "that hot air always rises," the installer can always provide for ventilation. Remember that the air must come from somewhere and must go somewhere and that the less interference offered to its passage, the better and cheaper the unit will run.

Do not place the refrigerator where it will accumulate dirt and lint because this will collect rapidly on the condenser and hinder the cooling of the unit.

A distributor of domestic refrigerators should adopt the following policy: When he receives a refrigerator or cabinet from the manufacturer he should set it up in his own shop and operate it for at least twenty-four hours before delivering it to the customer's home. Therefore, all the following should be done at the distributor's store.

149. SELF-CONTAINED UNIT METHOD OF PROCEDURE:

Speaking first of the self-contained unit, these cabinets are

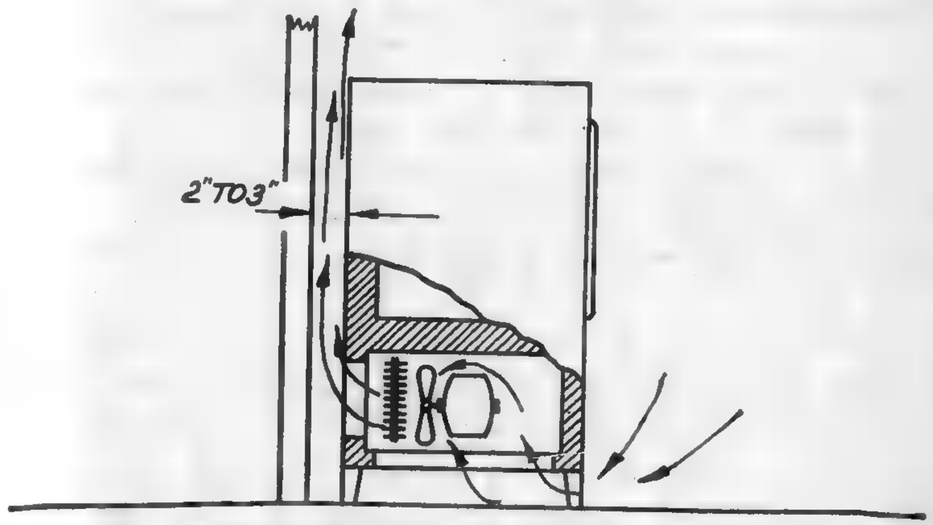


Fig. 142. Ventilating the condensing unit of a conventional cabinet

shipped ready for installing with only a few things to be done. A self-contained unit is that mechanical refrigerator in which the condensing unit is installed in the box. First of all, the refrigerator must be removed from its shipping crate. This should be done carefully so that the finish of the cabinet will not be harmed. Next remove the shipping bolts which hold the condensing unit base to the base of the cabinet. Then open the service valves and start the electric motor, and the refrigerator is ready to operate. The follow-

ing paragraphs explain in detail the usual procedure for the work.

After cleansing the inside of the refrigerator and removing the shipping bolts in the machine condensing unit base, the machine unit should be free to vibrate and there should not be anything obstructing the air circulation within the box. It is the usual practice for manufacturers to ship these units with all of the refrigerant stored within the condenser and liquid receiver tank, except in some of the flooded systems. Therefore, the first step to be made is to install service gauges—both low and high pressure on the equipment and to do this proceed as follows: Completely open both the suction service and discharge service valves until the gauge opening is completely closed. Remove the gauge opening plugs from the body of each of the valves; install the compound gauge in the suction service valve gauge opening, and the high pressure gauge in the discharge service valve opening. Next "crack" each of the valves to open the valve chamber to the gauges. Service men often equip their gauges with a short length of copper tubing in order to facilitate their installation and use. Then crack the liquid receiver service valve, Paragraph 198, until a pressure of 5 or 10 pounds is prevalent throughout the whole system. Test for leaks, see Paragraphs 189 to 193. Then increase the pressure to about 30 pounds for a final check-up for leaks. If there are no leaks, open the liquid receiver service valve fully, turn the compressor a few times by hand to make sure that it is free, and switch on the motor. Next, adjust the expansion valve to the proper pressure on the compound gauge if necessary. Specifications for this are always given in the distributor's service manual, also in Paragraph 88. Make a final check-up to see that everything is O. K. and allow the refrigerator to run for at least twenty-four hours.

If it is a low side float system having some of the refrigerant in the cooling coil, the valves on the cooling coil will be found closed. These must be opened after testing for leaks. The suction line valve on the cooling coil and the liquid receiver valve must be cracked to check for low side leaks and to test for leaks in the liquid line. Start the unit first and then open the suction line valve or the cooling coil slowly to prevent a high low side pressure. At the end of twenty-four hours check for refrigerating effect, for correct readings of the gauges, for correct box temperatures, and for normal operation in general. If the cooling unit is the brine tank type, check the level of this brine. It should be within $\frac{1}{4}$-$\frac{3}{8}$ inch of the top. See Paragraph 446 for brine solutions. Check the cooling unit if it is the flooded type for an even frost surface. An uneven surface indicates an oil-logged cooling unit. If everything is O. K. remove the gauges and replace the shipping bolts. The refrigerator is now ready to ship to the customer's home to be installed.

Occasionally, customers have ideas of their own as to where the refrigerator should be located, usually with an eye to their own convenience or to the beauty of the installation rather than to the practicality of it. It is wise to listen to these wishes but the distributor should spend enough time to make sure that the location is suitable from the standpoint of satisfactory operation of the refrigerator. A wise policy for a distributor or service man after installing a refrigerator is to call the next day and perhaps within a month after the installation has been made to check the operation.

150. THE REMOTE INSTALLATION OF THE ELECTRIC REFRIGERATOR:

The remote installation mechanical refrigerator is that one

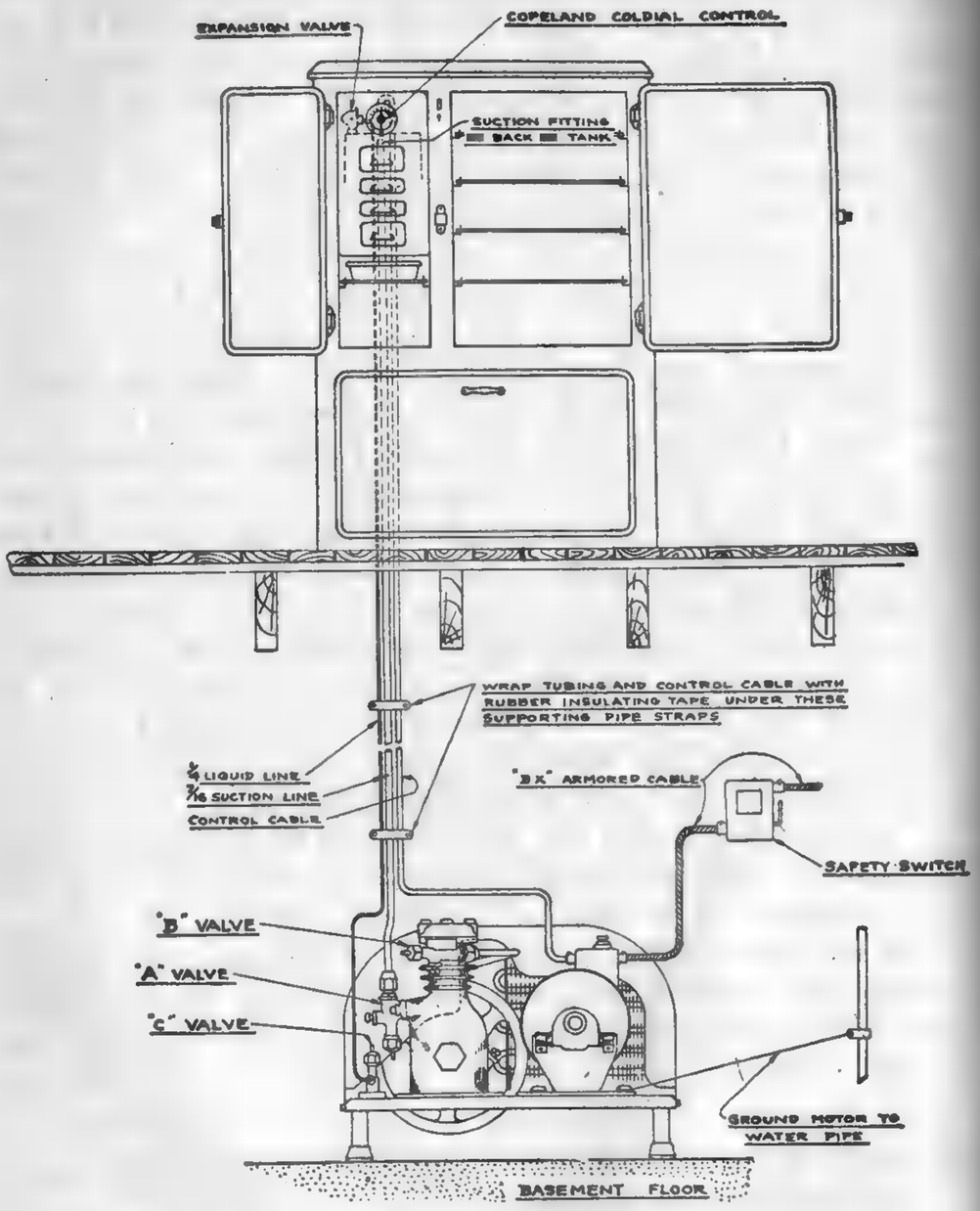


Fig. 143. Installing the condensing unit in the basement
(Courtesy of: Copeland Sales Company)

in which the condensing unit is not installed in the box but elsewhere such as in the basement. In a remote installation all of the above must be done with the added precaution that the liquid lines and the suction lines which are connected by the installation man must be cleansed of both air and water (dehydrated) before being permanently sealed. This is done as follows: Cut the tubing and put on the fittings, see Paragraph 224, making sure that they are the proper size and type for the suction and liquid lines for that particular sized compressor. (Check the service valve fittings.) Then make an installation of the same. An accepted grade of refrigeration tubing should always be used. Attach the liquid line permanently to the liquid receiver discharge service valve and fasten the other end to the expansion valve or tank valve loosely. Then crack the liquid receiver valve until one knows that there is refrigerant gas escaping from the loose fitting at the other end of the liquid line. This clears the tubing of air after which the joint may be sealed. Tighten the suction line permanently to the cooling unit and connect loosely to the suction service valve of the compressor. Then open the expansion valve of the cooling unit and allow refrigerant to escape into it and out at the suction line end. Let this continue until it is known that there is refrigerant gas coming from the loose fitting at the suction line of the service valve. Tighten up this fitting and the unit has been cleared of air and sealed. Figure 143. In this type of installation the rechecking of the machine is very important, especially for leaks.

151. DEHYDRATING OF TUBING, FITTINGS, AND COILS FOR REMOTE INSTALLATIONS:

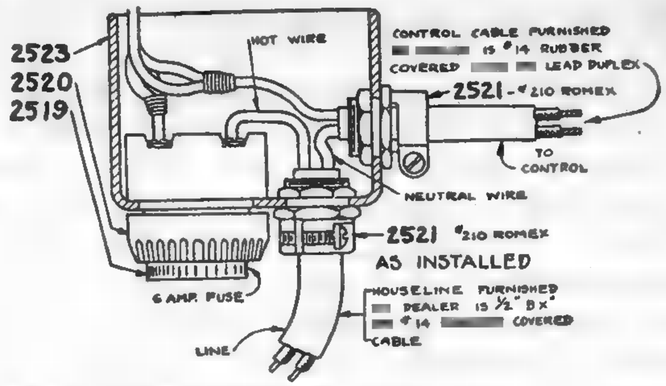
A further step in careful installation is to dehydrate the liquid line, suction line, and cooling unit by closing the liquid

receiver service valve and drawing as high a vacuum as possible. Use a torch to heat these three, being careful not to melt the soldered joints. This evacuating should continue for six or more hours. The evacuation should be to the air through a tube in the gauge of the discharge service valve with this valve turned all the way in. After clearing the tubing and other parts of air and moisture, test very carefully for leaks. When mounting the lines themselves, they should be firmly attached to the wall with fittings that will not mar the tubing, and the tubing should be mounted to allow natural flow of liquid to the condensing unit, to prevent slugs forming in the lines. Horizontal loops put in the lines before they are attached to the compressor will prevent vibration from breaking them. Run the lines together as much as possible, as this will increase the economy of operation. A rubber grommet should be used where the lines run through the floor and into the box. Needless to say, a lower suction pressure must be used because of line friction and more refrigerant must be used because of a longer liquid line.

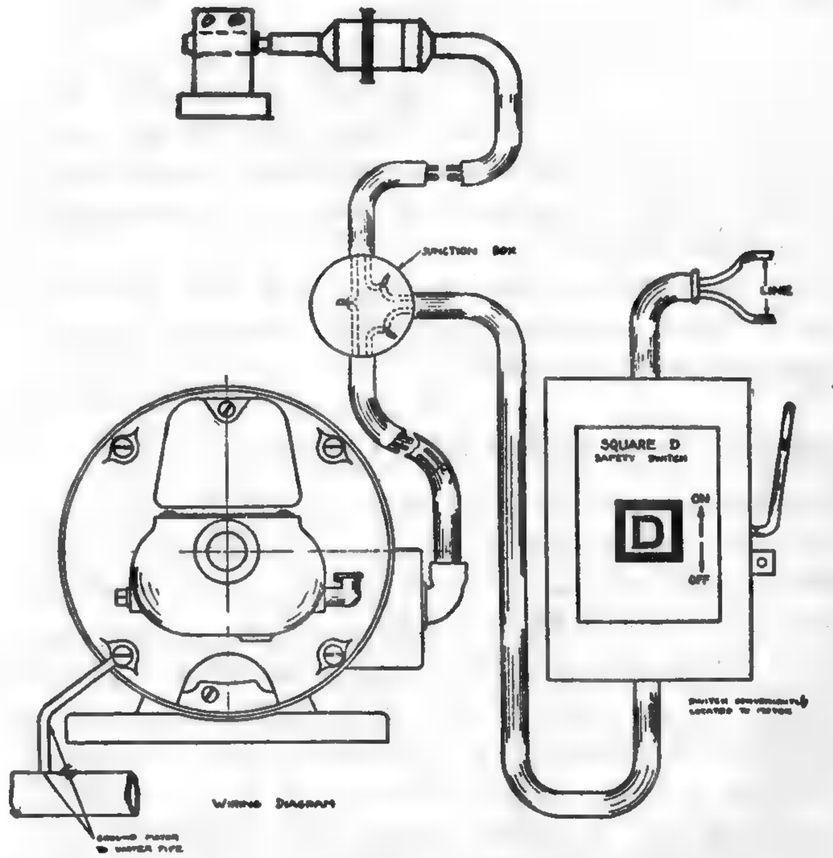
Those units which use float valves must be very carefully leveled in order to permit a satisfactory operation of the float valve.

152. HERMETIC MACHINES:

The above explanations deal only with the mechanical refrigerator equipped with service valves. Other types, such as the General Electric, the Majestic, the Servel, etc., do not require any of these special precautions because they are what are called hermetically sealed mechanisms and require only a correct electrical connection and proper ventilation when installing them. They should also be very carefully leveled because float refrigerant controls are usually used.



TERMINAL COVER WIRING



MOTOR AND CONTROL FULLY WIRED

Fig. 144. Electrical connections to the motor of a condensing unit
(Courtesy of: Copeland Sales Company)

153. ELECTRICAL CONNECTIONS:

In all the electrical refrigeration hook-ups it is of the utmost importance that the refrigerator motor have the same characteristics as the power line. The frequencies must be the same, that is, 60 cycle, 25 cycle, etc. The voltage must be the same, 110V, 220V, 32V. The phase must be the same, single phase, three phase, etc. Single phase motors are used almost exclusively for domestic refrigerators. Sufficient current must be available for motor consumption and the voltage must be up to the voltage required by the motor. Therefore, long household wiring cannot be used. To check up on these values an A.C. ammeter and voltmeter may be used. In most cases it may be advisable to install a new circuit for the refrigerator rather than use the supply already available in the kitchen, due to the fact that the refrigerator circuit should be as short as possible to eliminate voltage drop in the line.

One should know the local electrical code before attempting to install electric refrigerators. A typical hook-up is illustrated in Figure 144.

154. ABSORPTION REFRIGERATORS:

The absorption types of refrigerators are involved in a different complication in reference to installing, but this is offset by the simplicity of the installation as a whole. Most absorption type refrigerators have water-cooled condensers. This usually necessitates tapping the water system of the house. This is not difficult, but it must be carefully done and according to underwriter's code or any local rules which may affect such work. Also, a lead must be made from the gas line which will probably require the sanctioning of the gas company. Some city codes specify that the fuse plug opening in the refrigerant system must be vented to the outside

to prevent any chance of discharging the refrigerant into the house. Apart from these things nothing further need be done except following the general directions in the final part of this chapter.

155. GENERAL INSTRUCTIONS TO THE HOUSEWIFE:

Before leaving the refrigerator in the hands of the housewife it is very important that she understands the uses and abuses of the mechanism. Instruct her very carefully about:

1. Keeping the doors closed tightly
2. Leaving uncovered liquids in the cabinet
3. Placing hot foods in the cabinet
4. The correct position of different foods in the box
5. Leaving the doors open a minimum of the time
6. Methods of defrosting. *Do not use an implement for removing the frost*
7. The correct use of the temperature control
8. The proper way to cleanse the interior and exterior of the box and the ice trays
9. The precaution not to crowd the shelves with articles which will obstruct circulation

If possible, leave these instructions in written form attached to the refrigerator. Impress upon the owner that economy of operation and long life are dependent on the proper use of the unit. Leave name, address, and telephone number in a convenient place to allow a service call to be made with a minimum of trouble to the housewife.

156. WINTER SHUT DOWN OR MOVING INSTRUCTIONS:

Many people in the temperate zones feel inclined to shut off their refrigerators in winter to economize. This should

not be done if it is at all possible to keep the unit running. The unit has been well balanced and has settled to its task. To shut it off will upset its operation. The pressures will build up, and when the unit is started, it will be overloaded for a period; very often oil pumping results, causing such a disturbance that particles of dirt in the system start to circulate causing trouble. Another trouble is that after the oil pumping starts, the crankcase will be low on oil and in many cases the crankshaft seal will start leaking. To shut a unit off, one should pump all the refrigerant into the liquid receiver and condenser, balance the pressures, and close all service valves. See Paragraph 165 for detailed instructions for this operation. Refrigerators should be "pumped down" as above before being moved if the moving will take longer than six hours. Whenever a refrigerator is moved, the condensing unit should be clamped or bolted to the cabinet and not allowed to ride on the spring or rubber supports. The shipping bolts that were supplied by the manufacturer should be kept for this purpose.

157. REVIEW QUESTIONS:

The answers to the following questions may be found on page 815.

1. Define a self-contained installation.
2. Define a remote installation.
3. What clogs an air-cooled condenser, externally?
4. What should a distributor of refrigerators do to safeguard his good-will?
5. Explain a good method to provide positive rear ventilation of the base-located condensing unit.
6. What happens when a refrigerator is disconnected from the current supply for 48 hours or more?

7. Is the dehydration of a system absolutely necessary regardless of the refrigerant used?
8. Why must a unit be pumped down if it is shut off for any length of time?
9. Why is the tubing hole in the cabinet sealed?
10. Why is it best to allow a refrigerator to run without its being shut down?
11. Why should a hermetic refrigerator be installed in a level position?

CHAPTER XI

DOMESTIC REFRIGERATOR SERVICING

A competent service man must be very well acquainted with the fundamentals of refrigeration and must be adept in the proper use of tools before he is qualified to work on a refrigerator mechanism. A good knowledge of fundamental refrigeration is needed to dismantle and assemble the mechanism and to locate troubles. A knowledge of the handling of tools is necessary in order to lap valves properly, to fit tubing, and to assemble the parts in the proper manner.

The ability to locate trouble and determine its cause is the main qualification of a competent refrigerator service man. Practically any careful mechanic can overhaul a refrigeration mechanism once it is taken apart, but it requires a specially trained mechanic to dismantle and assemble a refrigerator, and it also requires special training to diagnose the troubles and make repairs on the mechanism. It is very important to read and study this complete chapter before attempting any repairing.

158. SERVICING CONVENTIONAL REFRIGERATOR UNITS:

As all of the reciprocating compressor type refrigerators are much the same, general instructions will apply to nearly all of them. This field includes the Kelvinator, Frigidaire, Copeland, Mayflower, Ice-O-Matic, Stewart-Warner, and many others.

159. DISMANTLING:

Generally speaking, to remove any part of the mechanism it is first necessary to remove the refrigerant from it. This

is done by the proper use of the service valves, the compressor, and suitable gauges installed in the system. Figure 145. The removal of any part is usually accomplished by drawing a low pressure or vacuum on that part to be dismantled in order to evaporate the refrigerant from it, and then by equalizing the pressure to 0 pounds per square inch or 1 pound per square inch gauge. The vacuum, of course,

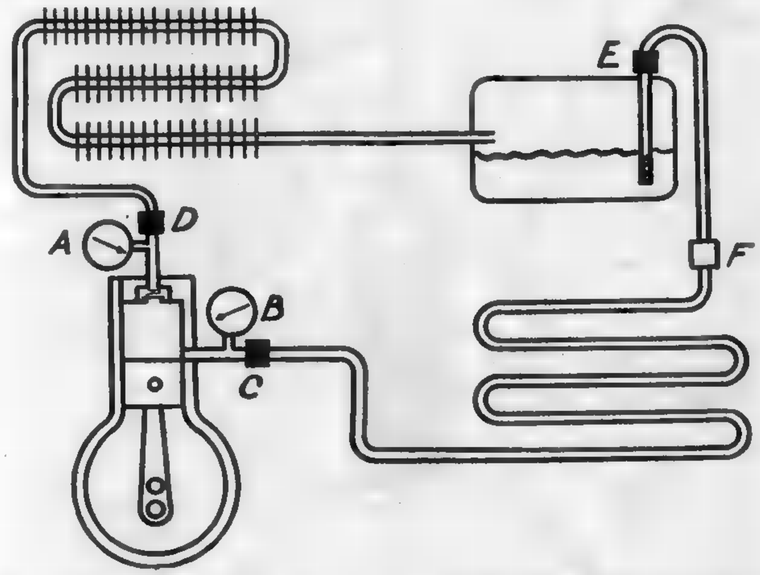


Fig. 145. A conventional compression system showing the location of the gauges and of the servicing valves

A. High pressure gauge; B. Compound gauge; C. Suction service valve; D. Discharge service valve; E. Liquid receiver service valve; F. Expansion valve

removes the refrigerant and the equalizing or balancing of the pressure prevents a rush of air into the mechanism or of refrigerant out, when the system is opened. This last step is very important.

160. TOOLS:

The tool kit for the following operations includes valve wrenches, gauges, storage cylinders for the refrigerant,

wrenches, and a torch. Figure 146. The service man is helpless without a proper array of servicing tools and this kit includes common and special tools. See Chapter XII for more detailed description of these tools.

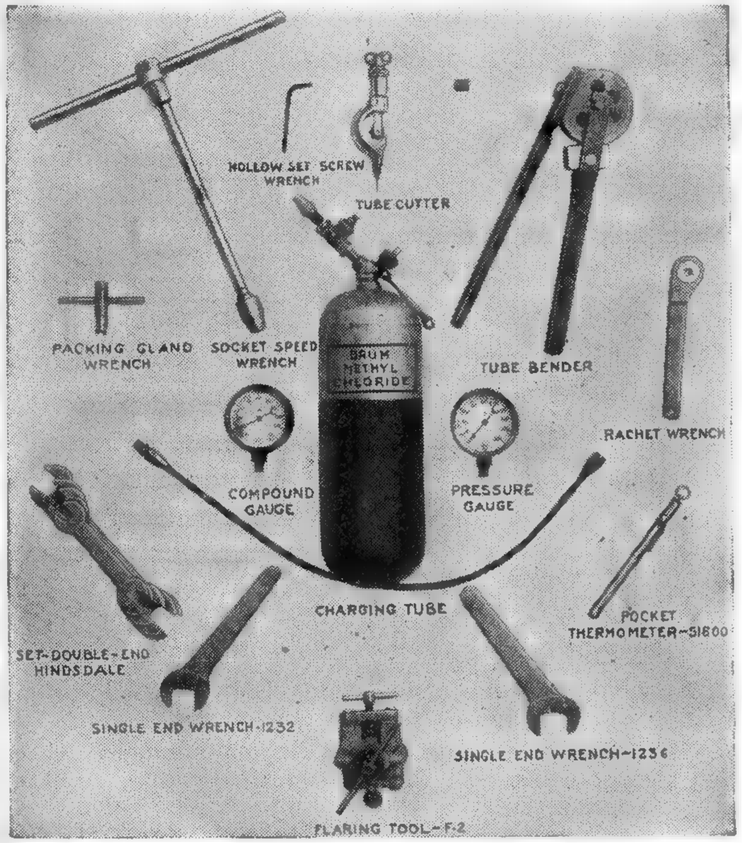


Fig. 146. A typical set of tools needed for servicing operations
(Courtesy of: Williams Oil-O-Matic Heating Corporation)

A complete service man's tool kit will comprise the following:

1 Refrigeration ratchet wrench with ¼ inch square openings

1 ¼ inch square to ¼ inch square ratchet wrench adapter
1 ¼ inch square to 3/16 inch square ratchet wrench adapter
1 ¼ inch square to 7/32 inch square ratchet wrench adapter
1 3/16 inch internal packing nut adapter
1 ¼ inch internal packing nut adapter
1 Set of bending springs for ¼ inch, ⅜ inch, and ½ inch O.D. tubing
1 Tube cutter
1 Flaring outfit to use on 3/16 inch, ¼ inch, 5/16 inch, ⅜ inch, 7/16 inch, ½ inch O.D. tubing
1 Compound gauge 30 inch Hg—0—90 pounds per inch
1 High pressure gauge 0—300 pounds per square inch
1 8 inch Crescent wrench with maximum jaw opening of 1 inch
1 ½ inch end wrench 15°
1 ¾ inch end wrench 15°
1 ⅞ inch end wrench 15°
1 1 inch end wrench 15°
1 ½ inch box wrench
1 ½ inch "Tee" socket wrench
1 3 inch screwdriver
1 6 inch screwdriver
1 8 inch screwdriver
1 Gasoline blow torch
1 Halide leak testing torch
1 Bottle of 28 per cent aqua ammonia
1 set of Allen set screw wrenches
1 5 pound cylinder of sulphur dioxide
1 3 pound cylinder of methyl chloride
1 Set of sockets with handles from 7/16 inch to 1 inch openings (12 point preferred.)

1 Pinch-off tool (For extreme emergencies only)
1 Thermometer —20° F.—0—120° F.
1 Set of fittings, i.e. nuts, elbows, unions, half unions, "tees", caps, plugs
1 Purging line (¼ inch x 15 feet) equipped with a needle hand shut-off valve and a check valve
1 2 pound can of lye for sulphur dioxide systems
1 Gasket scraper (ground file)
1 Glass lapping block
1 Can of refrigerant oil (spout type)

161. INSTALLING GAUGES:

A very careful procedure must be followed when one mounts the gauges on a refrigerating system to insure a clean system and a long life for the gauges. These gauges are either fastened directly into the service valves, by means of a ⅛ inch pipe or a ¼ inch pipe connection, or by short runs of ¼ inch tubing with which the appropriate fittings are used. The service valves on refrigerators in service are usually turned all the way out ready to receive the gauge in the gauge opening; however, the service man should always check to make sure that the gauge opening is closed off before removing the gauge opening plug.

The following is an approved procedure for installing gauges. First, loosen the packing nut one complete turn and then turn the valve stem all the way out. Paragraph 198. Clean the exterior of the service valve and then remove the gauge plug. Mount the gauge into the gauge opening, being careful not to twist on the gauge body; that is, do not tighten the gauge into the fitting by twisting with the hand, but rather use the proper sized wrench.

Now turn the valve stem in, using the fixed end of the service valve wrench, and turn it in only a very small part

of a turn. This is to prevent the rupturing of the gauge mechanism in case there is an excessive pressure released into the gauge Bourdon tube. Shut off the valve in case the pressure builds up too rapidly. Stop the machine, if necessary, to build up a positive pressure of from 5 to 10 pounds and then test for leaks. The gauge is now in position for use.

162. TO REMOVE A GAUGE:

Loosen the packing nut one turn and turn the valve stem all the way out. Remove the gauge (using a wrench), fill the gauge opening with refrigerant oil, and then install the plug. After the plug is tightened firmly into its seat, turn the valve stem back in about 1/16 of a turn; then tighten the packing nut. The purpose of putting the oil into the gauge opening is to have it serve as a lubricant to the valve stem and its packing. The purpose of turning the valve stem back in 1/16th of a turn is to prevent the valve from "freezing" against its seat. Such a condition occasionally leads to broken valve stems. Never tighten a cold gauge plug into a hot service valve. This results in a freezing of that plug into its seat and it probably will be very difficult to remove. When using the service valve wrench on these valves, never use a jerky motion. Always apply the turning force gradually. Adjustable end wrenches or fixed end wrenches are not recommended for service valve stems. Only the special socket wrenches, sometimes called keys, are to be used.

163. REMOVING ANY PART OF THE SYSTEM:

To remove any part of the system, one must:
1. Remove all the refrigerant from the part to be opened.
2. Balance the pressures in the parts just evacuated.

3. Isolate the parts to be opened from the rest of the system.
4. Clean and dry the joints to be broken.
5. All refrigerant openings should be immediately plugged as soon as they are opened.

164. TO REMOVE THE COMPRESSOR:

Install the compound gauge in the suction service valve by turning the valve all the way out. Take out the gauge plug, and screw on the gauge. Crack the valve (open slightly) and test for a leak at the gauge very carefully. See Paragraphs 189-93 for leak tests. In order to test for leaks, the pressure must be from 5 to 15 pounds gauge. Then turn the suction service valve all the way in (closing off the suction line). Figure 147. Start the compressor, but let it run for only a moment in order to eliminate oil pumping, for the oil in the crankcase will bubble vigorously due to the refrigerant coming out of it. Pumping of oil is indicated by a pounding noise in the compressor and usually occurs between a 10 inch and 12 inch vacuum. After starting and stopping the unit two or three times, it may usually be run continuously. Keep the unit running for a few minutes after a 22 inch to 26 inch constant vacuum is reached on the suction gauge. If a 22 inch to 26 inch vacuum cannot be obtained, it means that the compressor is inefficient or that the suction service valve is leaking. Stop the compressor and notice if the gauge creeps. If it does, this signifies that the exhaust valve in the compressor is leaking, that the suction service valve is leaking, or that the crankshaft seal is leaking. In this case the prevention of gas escaping or of air getting into the system will be difficult. This will necessitate a careful assembling of the unit to rid the system of air.

If the gauge does not creep, crack the suction service valve until the compound gauge reads zero or 1 pound pressure (equalizing the pressures). Then turn the discharge service

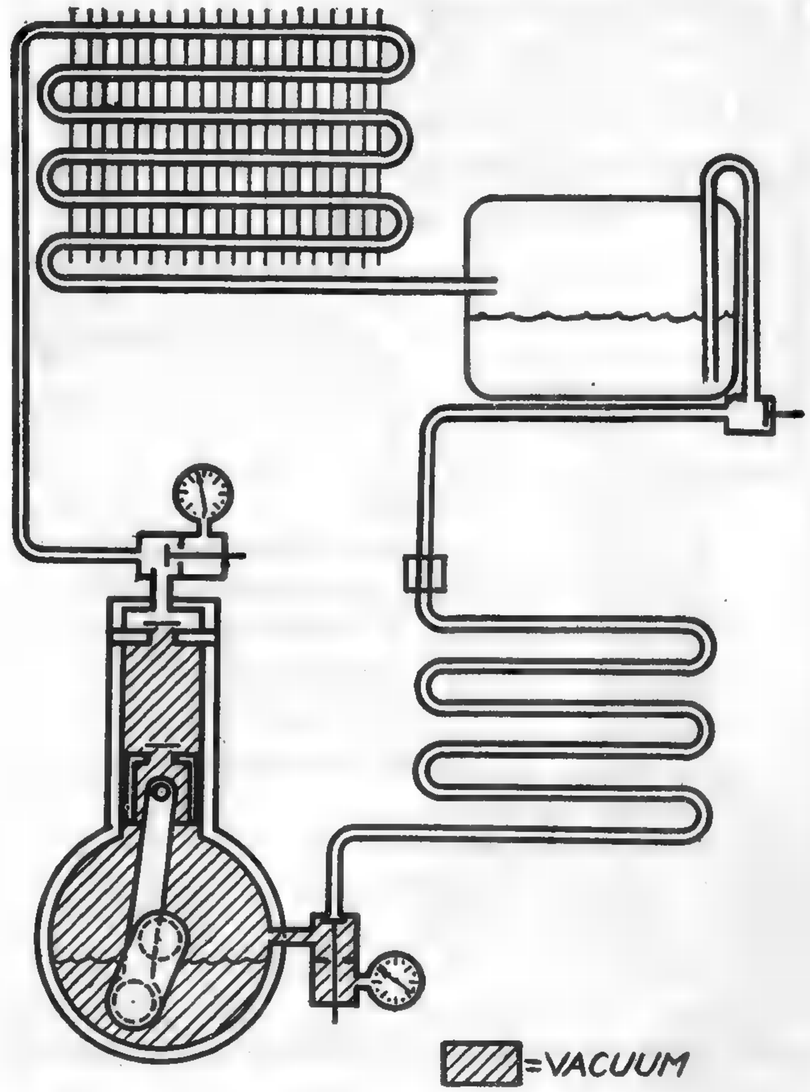


Fig. 147. An illustration showing the suction service valve turned all the way in and the compressor vacuated

valve all the way in, and unbolt the suction service and discharge service valves from the compressor (do not remove

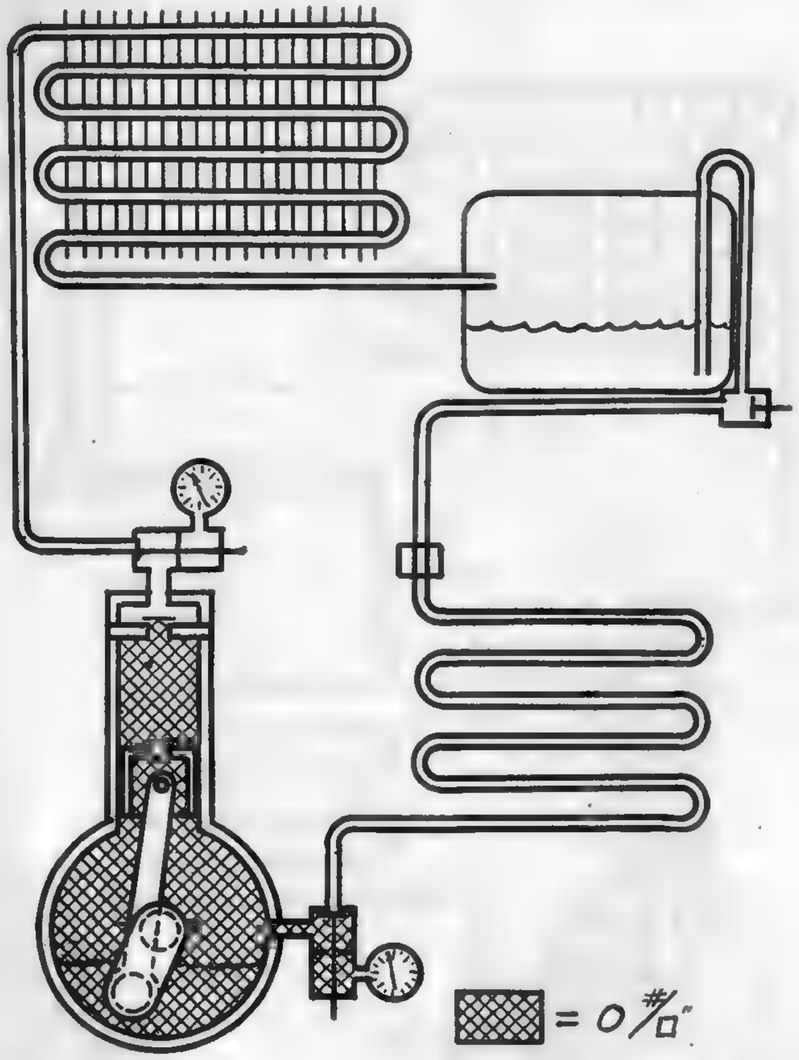


Fig. 148. An illustration showing the two compressor service valves turned all the way in and the compressor crankcase pressure balanced

the lines from the valve). The joints should be cleaned before opening. Figure 148. Immediately plug all the openings through which refrigerant flows using dry rubber or cork stoppers. Disconnect the compressor base bolts that hold the compressor on the base, remove the belt, and the compressor is ready for an overhaul. The oil (if it is to be used again) should be drained immediately and put in a sealed container to keep out dirt and moisture. However, one should never use the old oil again, especially if it shows any discoloration.

165. TO REMOVE THE COOLING UNIT (DRY SYSTEM):

Install a compound gauge in the suction service valve and test for leaks. Start the compressor and close the expansion valve by turning the adjustment all the way out. Run the compressor until a vacuum of 25 inches to 28 inches is maintained for a few minutes. To speed up this operation heat the cooling unit carefully with a torch. *Never allow it to get more than warm to the hand.* After stopping the motor, open the expansion valve a very little until the compound gauge reads zero (equalizing the pressures); then turn the suction service valve all the way in, closing the suction line. Clean and dry the suction line where it is connected to the cooling unit and also the expansion valve; then unfasten the suction line from the cooling unit and plug the openings with appropriate fittings. Do likewise for the expansion valve, being very careful not to loosen the expansion valve from the liquid line.

166. TO REMOVE AN EXPANSION VALVE AND COOLING COIL:

In case the needle of the expansion valve leaks, or if the expansion valve is screwed into the cooling unit instead of bolted, the above method cannot be used. The way to remove the expansion valve is as follows: turn the liquid re-

ceiver service valve all the way in, after loosening the packing nut, and run the compressor until a 20 inch to 28

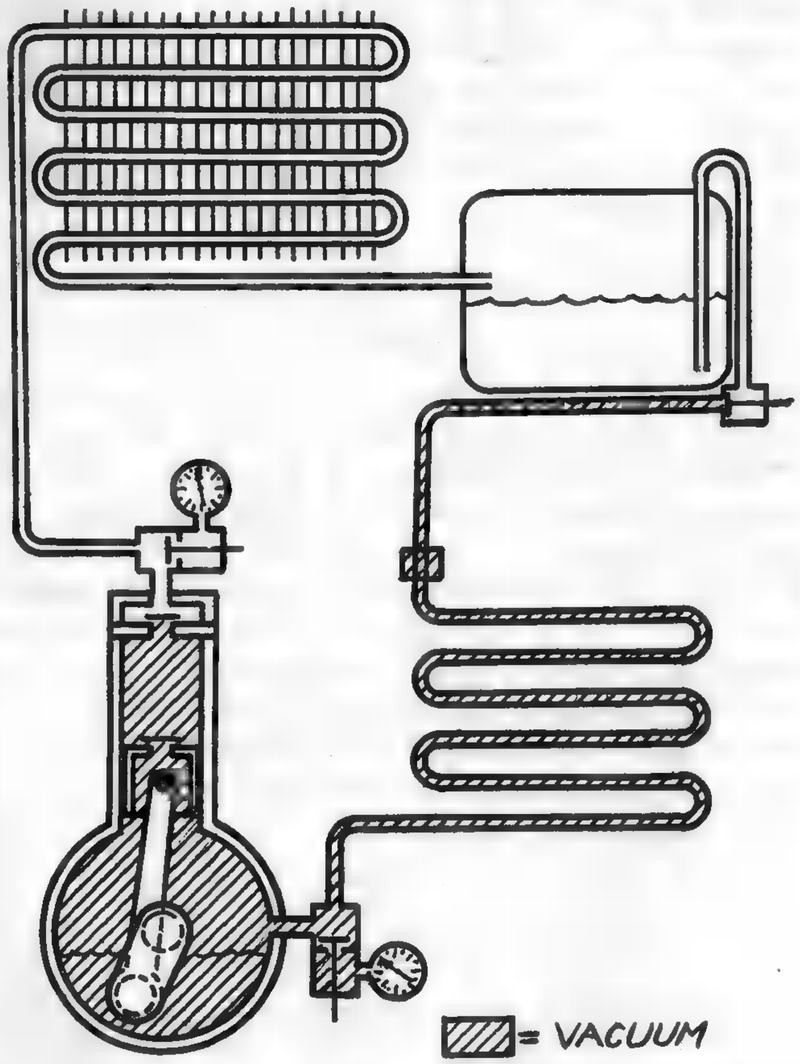


Fig. 149. An illustration showing the liquid receiver service valve closed and the compressor evacuating the liquid line and the low pressure side of the system

inch constant vacuum is reached. Figure 149. Now shut off the compressor and crack the liquid receiver service valve

until the compound gauge reads zero. If the system normally runs under a vacuum, the expansion valve will have to be turned in a turn or two in order to accomplish the above. After the pressures have been balanced, clean the connections remove them, and plug all the openings as stated above. This latter method is always used to remove an expansion valve.

167. TO REMOVE A HIGH SIDE FLOAT:

If the unit has a high side float, the method of removing the refrigerant from the low pressure side is as stated above; but to remove the refrigerant from the condenser and float chamber, the following procedure is recommended. If the float chamber is equipped with a purging valve, connect a line from this valve to the suction service valve of the compressor. Then connect a refrigerant cylinder to the discharge service valve gauge opening and turn the valve all the way in. Purge both of these lines and then start the compressor. As the compressor runs, it will pump the refrigerant out of the condenser and float chamber into the drum. A 22 inch to 28 inch constant vacuum will indicate when all the refrigerant has been removed.

Balance the pressure by "cracking" the discharge service valve, and the float may be removed. If one wants to keep the refrigerant in the cooling coil, turn the suction service valve all the way in. Clean the connections before breaking open any of the joints. A quicker way is to throw away the refrigerant in the float chamber by isolating the float chamber and then purging to the outdoors or neutralize with lye in case it is sulphur dioxide. (See paragraph 169.)

168. TO REMOVE A LOW SIDE FLOAT COIL:

There are two methods of removing the flooded cooling

unit and they depend on whether or not the refrigerant is to be left in the cooling unit.

1. The refrigerant may be left in the cooling unit if the cooling unit is equipped with service valves between the lines and the cooling unit. This method will necessitate leaving both the service valves on the cooling unit; therefore it will apply to all types of valved cooling units. To leave the refrigerant in the cooling unit, proceed as follows: close the liquid receiver service valve and run the compressor for about 20 seconds, in the meantime heating the liquid line slightly with a torch or by rubbing one's hand on it. Then close the liquid line valve located on the cooling unit. It is best to close this valve when the compound gauge is reading about zero pounds. The liquid line may now be disconnected and plugged after the exterior has been carefully cleaned and dried. Next, close the cooling unit suction line valve all the way in, and balance the pressures in the suction line by manipulating this valve. Now, clean and dry this connection and remove and plug the suction line. By carefully bending the suction line and liquid line to prevent the buckling of them, the cooling unit may be readily unbolted and removed from the cabinet.

2. If the cooling unit is not equipped with service valves, or if the refrigerant is to be withdrawn from the cooling unit, use the following procedure: Install a compound gauge in the suction service valve and test for leaks. Start the compressor and shut off the liquid line at the cooling unit if it is provided with bolted valves, or close the liquid receiver service valve if it is not. Continue to evacuate the cooling unit, heating it carefully as suggested to speed up the work until a 20 inch to 28 inch constant vacuum has been produced. Next stop the compressor and crack the cooling unit valve or the liquid receiver service valve until the

pressure has been equalized, that is, until the compound gauge reads zero. Now, turn the suction service valve all the way in; after cleaning the connections at the cooling unit, remove them very carefully, and plug all the openings immediately. If the cooling unit is equipped with valves, and the cooling unit liquid line valve has been shut off, this valve must be unbolted from the cooling unit. This means that it will be impossible to seal the cooling unit openings; therefore, the method whereby the liquid receiver service valve is the valve manipulated, is the best.

169. TO REMOVE THE REFRIGERANT, TO REMOVE THE CONDENSER, OR TO REMOVE THE RECEIVER TANK:

In this case, all the refrigerant must be thrown away or stored in an outside cylinder. Turn the discharge service valve all the way out and attach a line from a storage cylinder, if one is to be used, to the valve. Purge the line leading from the cylinder by sealing the line at the cylinder; then leaving it loose at the discharge service valve, crack the cylinder valve and the escaping gas will force the air out of the line. Seal the line at the discharge service valve, close the discharge line of the compressor by turning the discharge service valve all the way in, test for leaks, and start the compressor. Place the cylinder in a bucket of water in order to keep it as cold as possible. Figure 150. This will promote the condensation of the refrigerant in the cylinder. Allow the compressor to run with all but the discharge service valve open and with the expansion valve (if one is used) turned all the way in. However, the expansion valve should be opened carefully and slowly or the refrigerant will collect in the crankcase and will cause trouble upon removal. Shut the compressor off after a vacuum of

22 inches to 28 inches has been maintained for several minutes. When one does this operation the first few times, a high pressure gauge should be connected to the refrigerant

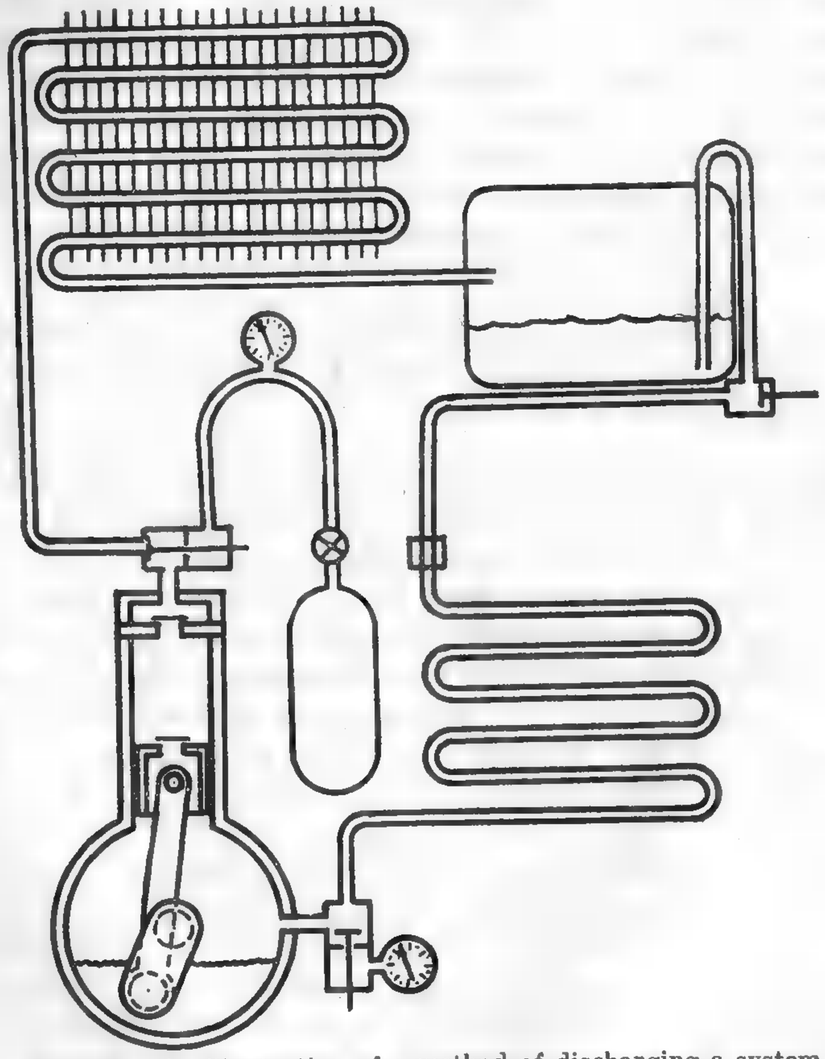


Fig. 150. An illustration of a method of discharging a system

cylinder to enable the service man to prevent an excessive head pressure from building up. The pressure should not exceed 125 pounds per square inch. Excessive head pressures may be avoided by cooling the refrigerant tank with ice, or water, or by running the compressor intermittently. Saving the refrigerant is not recommended in small systems because it might be saturated with dirt and impurities; the cost of 1 or 2 pounds of refrigerant is not excessive. Never allow the system to pump oil, as this will spoil any further use of the refrigerant in any system but the one it was removed from.

The refrigerant has now all been pumped from the system and is stored in the storage cylinder. The operation may be speeded up by applying a torch to the liquid receiver tank and to the cooling unit.

Close the cylinder valve and stop the compressor; then after opening the discharge service valve, crack the cylinder valve until a zero pressure is indicated on the compound gauge. This is to balance the pressure in the entire system before opening it to the air. Close the liquid receiver service valve and the discharge service valve, and the condenser and receiver may be removed from the mechanism. The above method is also known as removing the refrigerant. As mentioned before, clean and dry all the connections to be opened and immediately upon removal of any parts, the refrigerant openings should be carefully plugged. Whenever the service man wants to discard the refrigerant, he may either exhaust it to the air or in most cases (sulphur dioxide) discharge it into a neutralizer such as lye. One and one-half pounds of lye dissolved in 1 gallon of water will neutralize 1 pound of sulphur dioxide. A tubing with apertures in the side should be used and a large, deep, covered, non-metallic container should be used for the lye.

A good practice to follow when discarding refrigerants is to attach a purging line made of ¼ inch copper tubing to the discharge service valve gauge opening. This purging

line should have a hand needle valve and a check valve mounted in the compressor end of it. The hand needle valve should be located between the check valve and the purging line.

The purpose of the hand valve is to control the amount of gas purged while the check valve prevents the backing up of air or moisture into the unit after it has been completely purged. Another common practice for discarding refrigerants is to purge the gas down a sewer. This practice is not recommended due to the corrosive action of some refrigerants. If it is done, the water tap should be opened and the water allowed to flow rapidly in order to wash the refrigerant along.

170. REMOVING THE EXPANSION VALVE:

Install the gauges and test for leaks. Close the liquid receiver service valve and run the compressor until a 22 inch to 28 inch vacuum is maintained for a few minutes. Equalize the pressures by cracking the liquid receiver service valve. Close the suction service valve, dry and clean the expansion valve, and then remove the liquid line and unbolt the valve. Seal the refrigerant openings immediately. This method is similar to removing a flooded cooling unit not equipped with service valves.

171. REMOVING A FLOAT VALVE:

There are two types of float valves. First, the type which is completely removable including the float, the needle, and the refrigerant openings. Second, the cartridge type in which the header is welded to the body, the needle is built into a cartridge, and the float cannot be removed. The latter is usually the open pan type float.

1. To remove a bolted cooling unit float valve, the same procedure is followed as when removing the cooling unit itself with a few additional precautions. When doing the project, have the new float valve and a new lead gasket handy to enable one to do the job quickly. Also, tilt the cooling unit back before unbolting the header to prevent the oil from running out. *(Always remove the food from the box before working on the cooling unit.)*

2. A cartridge type of needle valve may be replaced using the same method as the above with the exception that the suction line does not have to be removed. The cartridge needle assembly that screws out of the header is all that needs servicing.

172. REMOVING A SERVICE VALVE:

Occasionally a service valve stem will break or the threads will strip, necessitating a replacement of the valve. If it is the suction service valve, one must remove all the refrigerant from the cooling unit and then balance the pressure unless the cooling unit is furnished with valves. To remove a discharge service valve or a liquid receiver service valve, the refrigerant must be removed from the entire system.

173. REMOVING THE ELECTRIC MOTOR:

It is a simple matter to remove the electric motor from any of these mechanisms because this operation needs only the removal of the drive belt and three or four bolts. First, remove the base bolts after scratching the position of the motor on the base; then slide the motor toward the compressor and remove the belt. The belt must be removed from the compressor pulley first because of the fan on the motor pulley. The electrical connections should be disconnected in the outlet box located on the motor. Mark these connec-

tions with tags, if necessary, and disconnect the power before untaping the joint.

174. REPAIRING:

Most of the mechanisms used in conventional refrigerating machines may be repaired and used again just as in automobile practice. However, the replacement policy is very popular and if the parts are available, this practice is to be preferred. Many orphan makes (the companies are no longer in existence), however, are still being used and parts cannot be obtained for them. With these machines in mind, the following instructions deal with reconditioning the old mechanism to work efficiently.

175. CHECKING THE COMPRESSOR:

Many refrigeration troubles are due to compressor failure. In most cases of refrigeration failure, it is advisable to check the compressor first to determine if it is operating satisfactorily. Naturally, a good service man will also look for other indications of troubles as he performs the check on the compressor. However, he should be certain that the compressor is in satisfactory operating condition before proceeding with other tests.

The two most common causes of compressor trouble are valves, and seals. Noisy valves may be detected by a sharp clicking noise in the compressor as it operates. Leaky valves may be detected as follows: install both the high pressure and compound gauges and test for leaks. Turn the suction service valve all the way in to close the suction line and then run the compressor intermittently. That is, turn the power on and off for a very few seconds at a time until the danger of pumping oil is stopped; then allow the compressor to run until a 28 inch vacuum or as good a vacuum as possible, has been obtained. Stop the compressor; if the compressor exhaust valve leaks, the high head pressure will produce a pressure above atmospheric on the compound gauge; therefore if the compound gauge creeps, it is a sign that the valve needs servicing, or that there is a leak on the low side (seal). Another way to check the efficiency of the exhaust valve of the compressor is as follows: mount the high pressure gauge, test for leaks, and turn the discharge service valve all the way in. *Turn the compressor over by hand.* If the discharge valve leaks, the pressure, as indicated on the high pressure gauge, will rise as the piston comes up; this pressure will leak back to its former value as the piston goes down. That is, if the gauge pressure fluctuates considerably, it is an indication of a leaky exhaust valve, but if the pressure merely increases and does not drop back to any extent, it indicates that the exhaust valve is not leaking. A worn piston or cylinder is indicated by a clicking noise which is somewhat duller than the noisy valve indication mentioned before. A compressor should be able to produce at least 20 inches of vacuum against its head pressure (depending on the refrigerant) to be good enough for use. The compressor must pump a specified quantity of gas at a certain pressure difference to do the work necessary; but this is too hard to check; therefore the above methods are used as secondary checks.

Compressor Testing Methods:

1. Vacuum producing ability
2. High pressure maintaining ability
3. Being able to hold both the vacuum and the head pressure

To test for leaks on the low pressure side of a compressor, such as at gaskets, at the suction service valve, or most commonly at the crankshaft seal, one may use one of

two methods. (1) Close the suction service valve and draw as high a vacuum on the compressor as possible, turning the discharge service valve all the way in. Keep the compressor running and if the head pressure gradually rises, it means that air is being drawn into the low side of the system. (2) A better way is to balance the pressures in the crankcase and turn the discharge service valve all the way in. Remove the gauge plug and connect a 15-inch copper line; then immerse the end of the copper line into a glass bottle partly filled with oil, with the compressor running. If the tube discharges gas continuously, as shown by air bubbles appearing in the oil, air is being admitted to the low side of the compressor. If there are no leaks, the bubbling will stop immediately after the compressor is started. To locate the leak, put refrigeration oil around one joint at a time; if air is leaking in at that point, the air bubbles will cease while the oil is being drawn in instead of air.

A poor intake valve will be indicated by a poor vacuum, but the compressor holds it when it stops. This may also be due, however, to too thick ■ gasket or worn pistons and rings. Another item to keep in mind is that a lack of oil will always result in poor pumping ability.

After the compressor has been overhauled, it should be charged with the correct amount of oil and tested. To put the proper amount of oil in a compressor, connect a tube to the suction service valve, run the compressor, and pump a vacuum with this tubing immersed in fresh refrigerant oil. The oil will quickly fill the crankcase. When it starts to spray through the discharge service valve, it is an indication that the compressor has enough oil. The compressor should next be equipped with a high pressure gauge and ■ compound gauge. Test to see if it will produce a 20 inch or more

vacuum against its head pressure (75 pounds per square inch for sulphur dioxide and 100 pounds per square inch for methyl chloride). If the compressor tests all right, it should be baked for a period of 8 hours or more at a temperature of 150° F. with a 20 inch vacuum on the crankcase or at 200° F. without a vacuum being drawn to remove all moisture.

176. VALVES:

Practically all of the valves of the domestic refrigerators

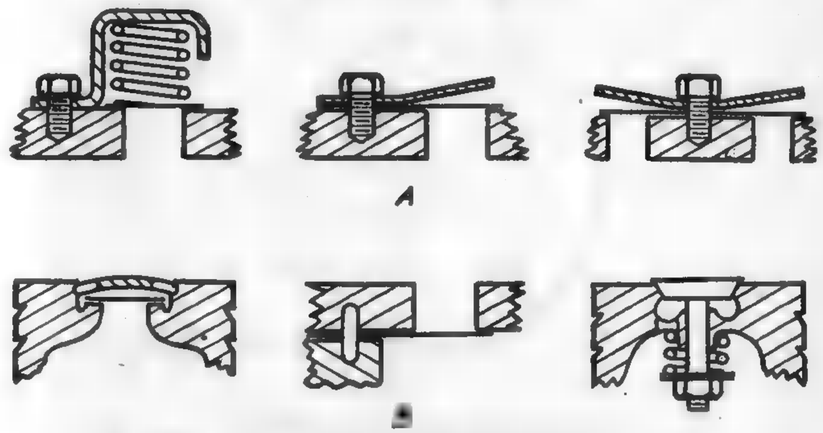


Fig. 151. Some typical compressor valve designs
A. Exhaust valves; B. Intake valves

are of the diaphragm or disk type, usually called ■ flapper valve. They are made of very thin spring steel with a smooth surface and are held in place either by their own spring tension and a machine screw or by an auxiliary coil or flat spring. Figure 151. After a long period of use the compressor valves wear and the valve seats which are usually made of cast iron may become worn. It is always a good policy to replace the valves when overhauling a compressor because their cost is very small. It is also good practice to lap the valve seats. There are many methods of lapping

these seats and all are satisfactory. The two things necessary are that a very fine lapping compound be used and special care must be taken to clean all lapped surfaces very carefully with carbon tetrachloride after lapping valve seats, otherwise the compound will ruin the compressor. Wherever raised valve seats are used, a plate glass surface may be used as the lapping tool, or one may use special lapping blocks. Some companies use fine polishing paper clamped to a flat plate as the lapping surface. Where the valve seat is in a very bad condition, the valve plate should be mounted in a

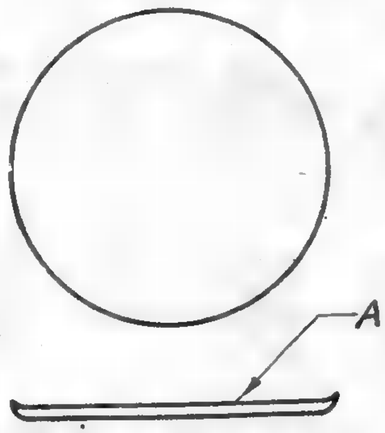


Fig. 152. A valve disk. The side (A) is to face *away* from the valve seat

lathe, either in a chuck or on a face plate, and the whole plate then trued up.

In compressors using the spring steel type of valve it is very necessary that the proper surface of the valve come in contact with the valve seat. This surface may be detected by the slightly turned-over edge of the opposite surface of the valve. This is caused when these valves are stamped out; the stamping process turns the edge of the valve on one side (burrs it) and if this side were placed against the valve seat, it might not seal properly. Figure 152.

177. REPLACING BEARINGS:

It is very seldom that any work has to be done on the connecting rod bearings or crankshaft bearings of these compressors, but if it should be necessary, it is a mere replacement and reaming process similar to some automobile work. Very close clearances are usually held in fitting compressor bearings. One of the most common sources of noise in a compressor is the piston pin. This pin must be replaced in practically all overhauls. Tolerances of .0005 of an inch are not too small. The fit must be very snug. Adjustable reamers, hand operated, may be used to ream the piston and connecting rod; if the pin itself is badly worn, a new one must be obtained. Some automobile pistons pins are usable in refrigerating compressors. Badly scored eccentric connecting rods must be replaced.

178. REPAIRING THE SYLPHON SEAL:

Sylphon seals usually have only two troubles, a squeaky noise caused by running the seal dry and a leaky seal caused by a scored seal surface. A noisy seal will soon become a leaky one if not attended to; it may be remedied by the usual process of lapping the seal (Figure 153), or it may sometimes be repaired by tapping the seal box lightly with a hammer. A more certain remedy is to wrap the bellows with oil-soaked wool yarn or string. A leaky seal may be detected by the usual test for leaks (ammonia for sulphur dioxide, etc., see Paragraph 189). Air in the system is usually the result of a leaky seal and this is detected by a high head pressure in sulphur dioxide systems, while it will usually cause a lack of refrigerant in methyl chloride systems. The usual symptom of this trouble that brings it to the attention of the housewife is a high power bill.

To lap in a sylphon seal properly, the work should be done with a special tool made of case-hardened steel with a ground surface. This tool with some oil-saturated lapping compound of a very fine texture is all that is necessary. In case a sylphon leaks, this operation should be gone

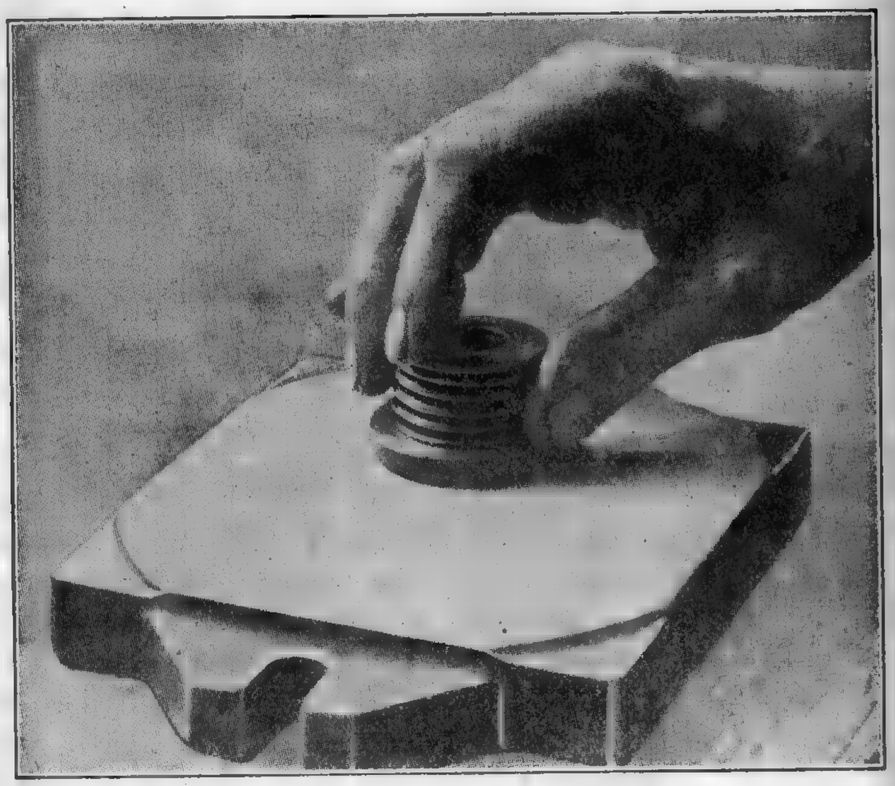


Fig. 153. Lapping the bronze ring of a sylphon seal assembly
(Courtesy of: Servel Sales, Inc.)

through and a new sylphon used. The crankshaft surface and the surface of the sylphon that come in contact should never have any scratches on them and should be of a burnished appearance in order to give satisfactory service. The contact surfaces of the sylphon and the crankshaft

shoulder must be perfectly square and polished. Figure 154. A scored crankshaft is best repaired by putting it in a lathe and polishing it with a high speed grinder. The amount ground away must be very small because the case hardening on these shafts is only .015 inch to .030 inch deep. Once this casing is ground through, the seal will not wear long. After the shaft is ground, it must be lapped in the lathe, using phosphor bronze or cast-iron lapping blocks and a very fine lapping compound under a light, even pressure.

Always use new gaskets when assembling the compressor. Lead or special paper gaskets are used on compressors. The

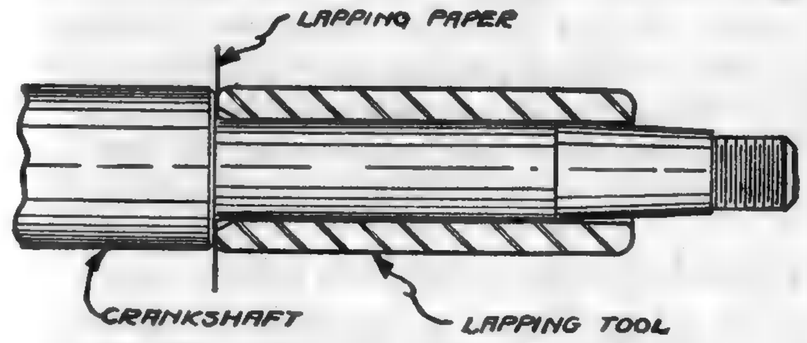


Fig. 154. Lapping the crankshaft seal shoulder

lead gaskets are the best, but they cost more. The thickness of the lead is between .010 inch and .020 inch. The paper gaskets, when used, must be of the same thickness as those removed and they must be thoroughly dry (dehydrated). When making a gasket, it must fit the chamber it is sealing. That is, the gasket that is placed between the exhaust valve plate and the cylinder must fit the cylinder with not more than 1/32 inch clearance. If this distance is made any larger, it reduces the efficiency of the compressor materially because it increases the clearance volume.

In case a compressor has been frozen due to a high head pressure or moisture in the refrigerant, it should be very

carefully cleaned and the piston and cylinder especially should be practically burnished in order to remove all the foreign substances. Xylene (pronounced zy′lēnĕ) will loosen a stuck-up sulphur dioxide compressor very nicely. Whenever a compressor is overhauled, new refrigerant oil should be replaced in the crankcase unless the old oil is not discolored. The compressor must be thoroughly dehydrated (baked) for 8 to 24 hours at 200° F. before it is used.

179. REPAIRING THE CONDENSER AND RECEIVER:

Whenever trouble is encountered with either the condenser or receiver, it will practically always be cheaper to replace them than to attempt to repair them. This is also true in regard to the cooling unit unless the flooded system is used. Welding, brazing, or soldering is sometimes used to repair leaks in the system, but it requires careful work.

180. REPAIRING THE COOLING UNIT:

In the flooded system the cooling unit trouble is most common in the float mechanism, and it is recommended that this particular unit be replaced rather than a repair attempted. It is necessary to point out here, however, that occasionally a service man will be led to believe that there is something seriously wrong with a part of the refrigerator when it is only some very small part such as a clogged screen or a pit in the needle valve seat. These small items which may cause trouble should be investigated thoroughly before the customer is made to purchase a complete new unit.

181. REPAIRING THE EXPANSION VALVE:

The four things likely to go wrong with the expansion valve are: the needle and seat becoming worn, a dirty screen,

a leaky bellows, and moisture accumulation on the outside of the bellows. Occasionally, one finds such trouble as a broken spring, etc., but it is very rare and is very easy to locate. A worn needle and seat is usually due to a lack of refrigerant in the system. The refrigerant does not have a chance to condense before it passes through the expansion valve orifice and this dry, hot gas cuts the needle and seat very rapidly.

To repair a needle and seat, one should replace with new parts. If replacements are not available, the needle must be reground or restoned in a lathe or drill press until the shoulder that has been worn into the needle surface disappears. It is very important that the same taper be kept on this needle point. The seat, which is nearly always made of a softer metal than the needle, may usually be filed until the old surface against which the needle was seated has disappeared. Then, one may tap the new needle into this new seat during assembly of the valve and get very good results.

A leaky bellows is due to a breaking down of the soldered joint, or to a fracture in the bellows itself; it is a very difficult thing to repair. The correct thing to do is to replace the expansion valve. However, clever soldering may sometimes repair the trouble. When any soldering is done on an expansion valve, the bellows must be immersed in water to keep it cool. It is very difficult to find the location of the leak in some particular instances; therefore, the following method will be found very useful: connect the expansion valve to a dry airline and build up a pressure of 10 to 15 pounds on the low side of the expansion valve by plugging the low side opening. Immerse the whole expansion valve in a quantity of gasoline or preferably carbon tetrachloride; the leaks will, of course, be indicated by bubbles.

The matter of successfully cleaning a screen is quite im-

portant. These very fine mesh copper screens may be cleaned fairly successfully by combining air pressure and carbon tetrachloride, but the best way is to dismantle the screen completely by heating it and unsoldering. This must be very carefully performed or the screen will be burned. It is important never to allow an expansion valve to go into service without a screen being placed in the liquid line entrance.

Moisture on the outside of the bellows is a result of air leaking into the housing surrounding the bellows and the natural condensation of the moisture in the air upon the cool surfaces. This moisture, when it freezes, binds the bellows and does not permit the expansion valve to operate at all, or permits only very erratic operation. Washing this part with carbon tetrachloride removes the moisture and prevents the recurrence of the trouble; the service man may do three things. (1) Put a quantity of vaseline in this space which will not allow moisture to accumulate, (2) Put a quantity of glycerine in this chamber which will combine with any moisture that enters and form a non-freezing mixture. (3) Place a rubber cap over the open end to exclude the air. However, the rubber usually is adequate protection.

To test an expansion valve after it has been repaired, one may use the following system. Join the liquid line connection to a dry air line and create at least a 90-pound pressure at the expansion valve. Turn the adjusting nut in until the valve is opened and permits the air to come through; then turn it out again until air ceases to pass by the needle. To test this accurately, pour some refrigerant oil in the cooling unit connection or low side opening of the expansion valve; if the valve is leaking, bubbles will be formed. No leak of any size should be permitted.

Another way to test an expansion valve is to connect a compound gauge into the low side of the valve and a high

pressure line on the liquid line connection. The compound gauge will give the various low side pressures for the different adjustments and will also indicate if the valve is leaking.

To test the bellows for leaks at this point, one may do it by plugging the low side opening of the expansion valve; then turn the adjusting screw in until a positive pressure of at least 30 or 40 pounds is produced on the inside of the bellows. Any leaks in the bellows will be indicated by bubbles coming through the oil that one places over the adjusting screw opening of the valve.

182. REPAIRING FLOAT VALVES:

The four things that most commonly occur as troubles with low side float valves are: a leaky needle and seat, a clogged screen, a leaky float, and the float mechanism out of calibration. The needle and seat are repaired precisely as those of the expansion valve explained above. This also applies to the screen.

It is a very difficult trouble-shooting operation to locate a leaky float ball. A very small pin hole in a float will permit the refrigerant to enter the interior of the float slowly and weigh it down. This will result in the needle being held open all the time. The best way to test a ball type float for a leak is to immerse it in very hot water. Do this very gradually so as not to disturb the water; the air on the inside of the ball on becoming heated will expand and come from any leak that may be existent in the ball. To solder a pin hole, the ball must be preheated.

One of the most difficult repair jobs is the calibration of the float. By calibration is meant the level of the float needed to close the orifice. If the float level is too low, the unit will short-cycle in case of a pressure control, or will give an unsatisfactory box temperature in case of a thermostatic con-

trol, because the area of evaporation of the refrigerant will be reduced.

About the quickest way to test a low side float is to mount the float in an almost vertical position, just enough off vertical so that the float tends to keep the needle pressed lightly against the seat. Be very careful not to allow the float to lean over to one side. Connect the liquid line opening to a dry air line and build up a 90 pounds per square inch pressure in it. Put some refrigerant oil around the needle and seat; the appearance of bubbles will indicate a leak. If the needle is leaking just a little, a light tap on the needle will sometimes seat it firmly in its seat and it will give satisfactory results. Remember, however, that this sort of repair should only be done in case one knows that the needle has no shoulder on it and that the seat is not too wide.

183. REPAIRING THE HIGH SIDE FLOAT:

There are two types of high side float systems used in domestic refrigeration. The type that uses the high side float located near the cooling unit has troubles very similar to the low side float mechanism. The only difference one must keep in mind is that the operation of the mechanism is opposite to the low side float. In the other type of high side float system, where the high side float is located in the liquid receiver, and where a weight check valve is used between the liquid line and the cooling unit, the following troubles may be incurred. (1) As for the float itself, the troubles are naturally similar to the low side float troubles and the methods of repair may be considered the same. (2) However, the weight check valve lends an additional servicing problem. This valve may be either stuck open or stuck closed. In the first case a decided frosting of the liquid line will be the indication of trouble. If the needle is stuck

closed, naturally one will get no refrigeration and a compound gauge will indicate a high vacuum on the low side. Then if one cracks the fitting connecting the liquid line to the weight check valve and finds liquid refrigerant at this point, it will show that the weight check valve is the trouble. These valves are very small and inexpensive and one should replace them as often as necessary; however, in case a new one cannot be obtained, these valves may be dismantled by either unsoldering or unbolting them, and the repair of the needle and seat is similar to what has been explained above. To test this valve, it is best to try to force the air backward through the valve. Be very careful to keep the valve right side up. One trouble encountered in the high side float is that overcharging will flood the low side with refrigerant, frosting the suction line and perhaps the compressor base.

184. ASSEMBLING THE REFRIGERATING UNIT:

When the repairs have been made, and the parts, after a rigorous testing of them, are considered all right, the problem of assembling the apparatus to insure correct operation is very important. Only a careful observance of certain fundamentals will make possible an assembly which will assure an efficient running unit. The four fundamentals to be followed when installing a part of a refrigerating mechanism are: (1) Clean and dry the part to be put in the system. (2) Purge and evacuate that part of the system which has been opened. (3) Test for leaks. (4) Start and adjust the unit.

If a compressor overhaul has just been completed, the installation of the compressor must be very carefully done or the repair job will be unsatisfactory. After bolting the compressor to the base and lining it up with the electric motor so that the belt is installed properly (see Paragraph 449),

bolt the suction service valve and the discharge service valve to the compressor. Install the compound gauge in the suction service valve, remove the plug on the discharge service valve, and exhaust the compressor to the outside until a vacuum of 25 inches to 28 inches has been drawn upon the crankcase for several minutes. Care should be taken, however, to guard properly against oil being thrown from the discharge service valve; if the compressor pumps oil, a cloth or sponge held over the discharge service valve opening is usually sufficient. After a sufficient vacuum has been drawn, the compressor should be heated thoroughly with a torch in order to expel all traces of moisture and air. The temperature for this should be upwards of 200° F. To complete the operations of putting the compressor in service, crack the suction service valve very slightly and allow some refrigerant to escape into the crankcase until a 5 to 30 pound pressure is obtained. Then test very carefully for leaks. Close the suction service valve completely and with the discharge service valve still closed, start the compressor and evacuate again to a 25 inch to 28 inch vacuum. This evacuation should be to the open air of the room or piped to the outside and not discharged into the condenser. The discharge service valve is turned all the way in during this operation. After the second vacuum has been drawn, replace the high pressure gauge in the discharge service valve; open both the suction service valve and discharge service valve all the way out but not far enough to close off the gauge openings. As this is done, however, it is a good policy to start the compressor again; otherwise there might be a flow of refrigerant from the cooling unit to the crankcase of the compressor and it is liable to freeze it when starting the compressor. This would cause a pumping of oil.

Leave the gauges attached to the mechanism until the expansion valve has been adjusted to the correct operating pressure and also check up on the condensing pressure which will tell whether the unit is working correctly. If convenient, it is recommended that these gauges be left on for a period of twenty-four hours or so in order that any unusual trouble may be quickly detected. However, this practice is usually not possible. In this event a service call should be made within the next day or two to check up on the operating pressures and the general condition of the refrigerator.

185. INSTALLING THE COOLING UNIT:

In the event the cooling unit has been removed, several important things must be remembered during the assembly in order that the apparatus function properly. After bolting the cooling unit back into the refrigerator and leveling it, remove the plugs on the refrigerant openings and attach the liquid line and suction line of the cooling unit. Be very careful during these operations that no moisture be allowed to enter the lines. It is good practice to dry the surfaces of the lines and cooling unit before removing these seals.

If the cooling unit is of the dry system, the expansion valve should be installed using a new gasket if it is of the bolted type. This ruling should be maintained on all refrigeration overhauls because it is taking a foolish chance to use old gaskets when the installation of new ones costs so little. To continue with the installation, loosen the compressor end of the suction line and crack the expansion valve allowing some refrigerant to escape forcing the air out of the cooling unit and suction line. The compressor end of the suction line should now be tightened. Another method is to evacuate the cooling unit, suction line, and compressor twice

to the air; the trapped air will then be drawn out of the system. The discharge service valve must be turned all the

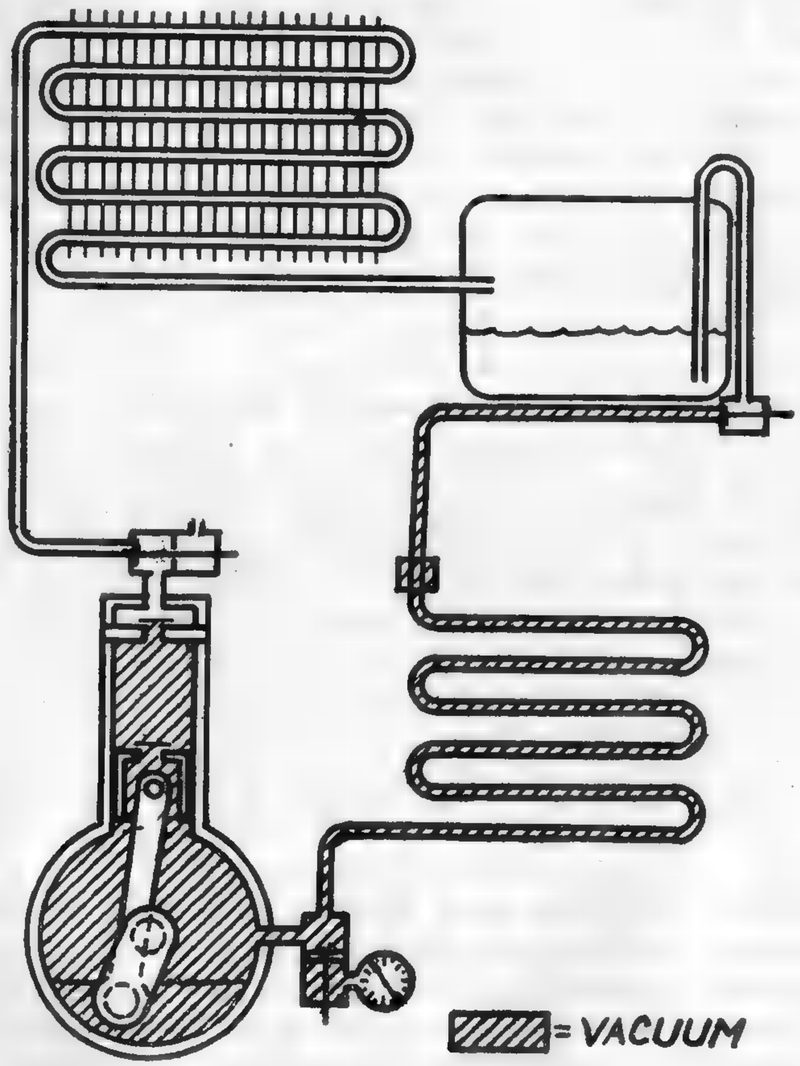


Fig. 155. An illustration showing the compressor evacuating the liquid line and low pressure side to the open air

way in during the evacuation, and the gauge plug removed. Figure 155. Test for leaks with a 5 to 25 pounds per square

inch pressure before allowing the refrigerant to escape into the unit.

The cooling coil may be dehydrated more completely by heating it to a fairly high temperature of (175—200°F.) as it is evacuated to drive out any moisture that may be present.

If a flooded system cooling unit equipped with service valves is used, bolt the valves to the unit, open the suction valve, and evacuate to the outside. Crack the liquid line valve, test for leaks, and evacuate again. This will clean the system of air. Close the compressor exhaust opening, open the cooling unit liquid valve, and the unit is ready to operate. In a case in which the cooling unit is not equipped with valves, the liquid receiver service valve must be used as the purging valve.

186. INSTALLING THE EXPANSION VALVE:

Mount the expansion valve and evacuate the liquid line, the cooling unit, and the suction line. Test for leaks carefully by purging and then evacuate again. Close the expansion valve, open the liquid receiver valve, start the compressor, and adjust the expansion valve to the correct low pressure. If the expansion valve is left open when the liquid receiver service valve is opened, the compressor crankcase will be flooded, lengthening the time of the service call unnecessarily.

187. INSTALLING THE FLOAT VALVE:

Install the float valve, evacuate, purge, and then test for leaks. Evacuate again and then seal the compressor, open the liquid receiver service valve and start the compressor. Be sure that there is some oil in the float valve or the float

will not be adjusted right (one-quarter pint of oil is usually sufficient).

188. SUMMARY OF REFRIGERATOR MECHANISM REPAIRING:

If the above instructions have been studied carefully, the student should recognize the following important things:

1. It is necessary to remove the refrigerant from that part of the mechanism to be overhauled.

2. It is necessary to equalize pressures in the unit before dismantling or there will be a rush of air *into* the unit or of refrigerant *out* of the unit upon breaking the lines.

3. It is necessary to plug all refrigerant openings immediately after dismantling.

4. It is necessary to put in new gaskets wherever they are used.

5. It is necessary, upon reassembling, to remove all the air from the lines and whatever part that has been open to the air; this may be done both by evacuating and purging.

6. To remove any part of the system it necessitates the closing the closest valve between that unit and the liquid receiver tank, and evacuating the unit by means of the compressor into the condenser and liquid receiver tank. If more than one method is available to do the operation, the best one naturally is the one that can be done in the shortest possible time because lingering on the job only adds to the inconvenience of the people in the residence where the work is being done. Always remove any tedious task to the shop to be worked on and, in the meantime, replace the unit with a temporary unit in order that the owners may still have the use of their refrigerator.

189. TESTING FOR LEAKS:

After any installation, or the replacement of any part of the refrigerator circuit, it is absolutely necessary that a very rigid test be made of all the joints to make sure that they are leak-proof. The methods of testing for leaks vary with the different refrigerants used. However, they are common in this respect: a positive pressure (greater than atmospheric) of from 5 to 30 pounds is necessary throughout the circuit in order that one may test for leaks.

190. TESTING FOR SULPHUR DIOXIDE LEAKS:

A very efficient test for a sulphur dioxide leak is an ammonia swab, that is, a small piece of ammonia-soaked cloth fastened to the end of a stick. The ammonia must be quite strong, the minimum strength being 26 per cent. This is stronger than household ammonia and the best place to obtain it is at the local drug store. Place this swab adjacent to all the joints or places where leaks may occur; if there is a leak, it will be made noticeable by a thick white smoke forming at the joint. Be very careful not to touch the metal with the ammonia as it will corrode the fittings.

The neatest method is a double pressure test especially if the testing is being done in the owner's home. First, produce a pressure of 3 to 5 pounds throughout the low pressure side of the system. Then test for leaks and if one is present this low pressure will cause the escape of very little refrigerant before the leak is detected. Then increase the pressure up to 30 pounds and test again. Occasionally a leak is found at this higher pressure which is not detectable at the lower pressure. If the service man were to test immediately at 30 pounds pressure, there might be such a bad leak present that the entire room would become filled with the refrigerant before he had a chance to stop it and it would also cause the leak of so much of the refrigerant that the exact source would be hard to detect.

191. TESTING FOR METHYL CHLORIDE AND ISO-BUTANE LEAKS:

In case it is a refrigerator that uses methyl chloride, Freezol; the refrigerant such as the Copeland, Ice-O-Matic, and others use, the method of finding the leak is quite different. First, all the grease and oil must be removed from the joint suspected of leaking, and then using a soap and water solution or oil, test all around the joint for a leak. If bubbles are formed, refrigerant is escaping. In case the unit under test is not hooked to the refrigerating circuit, it may be tested by submerging it in a water bath after being put under a thirty or forty pound pressure. That is, a test similar to testing leaking inner tubes may be used. A small mirror and a flash light may be used to inspect inaccessible places.

Test all joints very carefully because even a very minute leak will cause a complete loss of the refrigerant in a relatively short period. The halide lamp is an excellent means for testing for methyl chloride leaks (Paragraph 193).

192. TESTING FOR AMMONIA LEAKS:

In the ammonia system, such as the absorption type, two methods for testing leaks may be used. One is a sulphur candle which will give a very thick, white smoke if it comes in contact with leaking ammonia, and the other is to test with moist phenolphthalein paper, which will change its color instantly upon coming in contact with ammonia. Both of these tests are very rapid, convenient, and accurate.

193. TESTING FOR FREON, CARRENE, AND ETHYL CHLORIDE LEAKS (HALIDE TORCH):

To test Freon (F-12), Carrene, or ethyl chloride, for leaks, a very good method has been devised, but it requires special

equipment. It is an alcohol (halide) torch with a long air intake tube. Figure 156. With this alcohol torch ignited, pass the intake tube near the different joints. If some gas is leaking out it will go up the intake tube to the flame and give forth a brilliant green hue, a sure indication of a gas leak. A halide torch should be filled with alcohol and pumped up with air out-of-doors or in a room in which

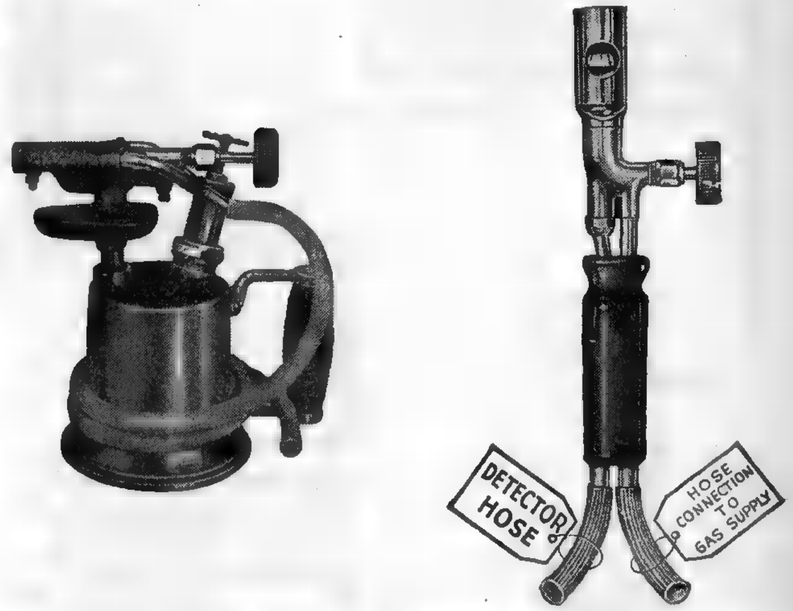


Fig. 156. A halide torch used for testing Freon, Carrene, ethyl chloride, methyl chloride, Thermon, and F-112 for leaks. A. Uses alcohol; B. Uses gas
(Courtesy of: The Hull Mfg. Company)

there is no possible chance of gaseous refrigerant being present; otherwise, if some refrigerant were pumped into the torch in charging it, it would give a continuous indication of the presence of a leak and would therefore be of no use in detecting leaks in a refrigeration mechanism. These gases may also be tested for leaks by the soap solution method or by immersion in water.

194. CHARGING THE REFRIGERATOR:

All of the conventional compressor type refrigerators are charged with refrigerant in the same general way. The

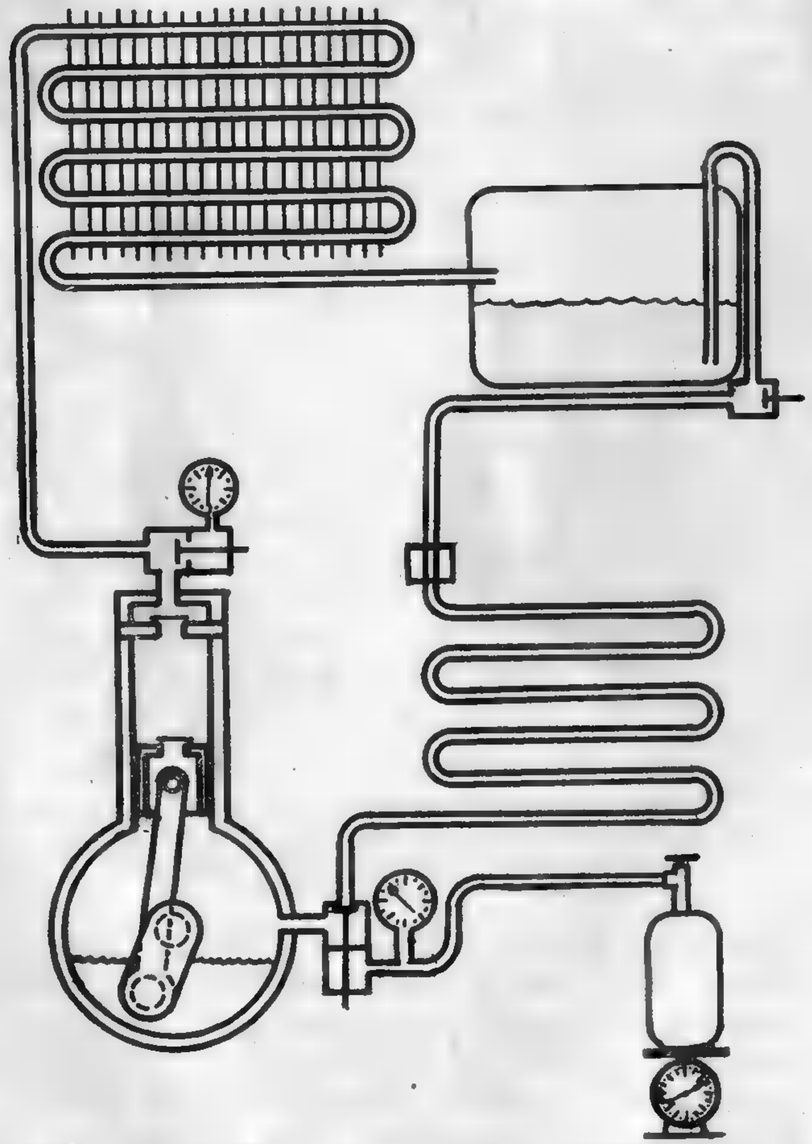


Fig. 157. An illustration showing a set up for charging refrigerant into the low pressure side of a system. Note the provision for weighing the refrigerant

easiest method is to charge into the low side of the cycle. This may be done as follows: Turn the suction service valve until the gauge opening is closed and attach a line from a charged refrigerant cylinder. A horizontal tubing must be used here which should be at least 4 feet long in order to permit accurate weighing of the refrigerant. Figure 157. Purge this line as follows: leave the fittings at the suction service valve end of the line loose, crack the cylinder valve, and the escaping refrigerant will remove all the air from the line after which the joint may be tightened. *Test for leaks.* Then turn the suction service valve all the way in so that the suction service line is closed. Place the refrigerant cylinder upon a scale in order that the quantity of refrigerant removed from it may be weighed. The cylinder must be held in an upright position while discharging into the compressor. Start the compressor, and operate it until enough refrigerant has been removed from the cylinder into the unit; then close the cylinder valve and stop the compressor.

Remove the cylinder by turning the suction service valve all the way out so that the gauge opening is closed and remove the line. Install a compound and a high pressure gauge and start up the unit. The gauges will indicate whether the unit is operating correctly or not. Adjust the pressures and test for leaks. Then remove the gauges, install the plugs, and the refrigerator is ready for use.

Another method of charging the refrigerator is to attach the line from the charged cylinder to the gauge opening of the discharge service valve and to drive the refrigerant out of the cylinder by heating it with a torch. This makes the running of the compressor unnecessary, but it requires the use of a torch. *The cylinder must be inverted.* If a torch is not available and the refrigerator is already partially

charged, a pressure can be built up in the refrigerant cylinder by turning the discharge service valve all the way in with the suction service valve open, then run the unit. This will build up a high pressure in the cylinder while the condenser is cooling. Stop the compressor and then turn the discharge service valve out a few turns. The pressure will force the liquid into the condenser and liquid receiver.

195. REMOVING AIR FROM THE CONDENSER:

After charging the refrigerator mechanism it is well to go back within a day or so and check the operating pressures again, because there is a chance that air may have leaked into the system. Air in the system will be indicated by a high head pressure even after the unit has cooled down. It may be removed by cracking the gauge opening on the discharge service valve. A tube fastened to the gauge opening should be led out-of-doors to avoid releasing the fumes in the house. A purge of 10 to 15 seconds will be of sufficient duration to remove the air if the condenser is cold. This is possible because the air is non-condensable; therefore it will collect in the top of the condenser as the lower end is sealed with liquid refrigerant. If it is an irritant gas, the purging line should be run outdoors or into a sewer with running water.

196. TRANSFERRING REFRIGERANTS:

It is good economy to purchase refrigerants in 50-lb. and 100-lb. quantities in large cylinders. This necessitates the transferring of the refrigerant from these large cylinders to the 5-lb. cylinders used by the service men. Figure 158. The transfer of the refrigerant is done as follows: invert the large drum in some special stand and connect it to a small drum with a horizontal tubing at least 4 feet long.

Purge this line and then open both valves after placing the small cylinder on a weighing scale. Sometimes the large cylinder must be heated to force the liquid into the small cylinder. When the small cylinder is charged with the correct amount, close the valve on the large cylinder and then heat the line. This will force the liquid out of the line. Next, close the valve on the small cylinder. Never allow the line to become more than warm to the hand. When applying the torch to the larger cylinder, keep it below the liquid level and away from the safety plugs.

Cylinder			Weight in Pounds of			Ammonia			
Weight (Pounds)	Height (Inches)	Dia. (Inches)	SO_2	Methyl Chloride	Iso-Butane	Height (Inches)	Dia. (Inches)	Weight in Pounds	
								Tare	Net
4	13½	4	5	3	1	.....	.....	.....	.....
4	24	4	10	6	2	.....	.....	.....	.....
■	26	6	25	15	7	.....	.....	.....	.....
36	44	8	70	40	.....	46	10	105	50
90	59	8	.....	60	.....	.....	.....	.....	.....
.....	40	10	100	60	.....	84	10	175	100
90 or 100	55	10	150	90	.....	84	12	204	150
115	54	121	.....	130	.....	.....	.....	.....	.....

Fig. 158. Table of refrigerant cylinder capacities

A charging board is the most accurate means of transferring refrigerant. (See Paragraph 246.) An important safety precaution needs to be taken. When transferring refrigerant from a storage cylinder to a service cylinder, *never fill a service cylinder completely full of liquid refrigerant.* This is particularly dangerous in cold weather since liquid refrigerant expands and contracts greatly with a change in temperature. If a service cylinder is filled completely full of cold liquid refrigerant and then brought into a warm room, the liquid tends to expand and the resulting

increase in pressure will burst the service cylinder with possible serious consequences.

197. DISCHARGING THE REFRIGERATOR UNIT (REMOVING ALL THE REFRIGERANT):

To discharge a refrigerator, a method is used similar to removing the refrigerant from the condenser and liquid receiver which has been explained previously in this chapter. It simply consists of fastening an empty or a partially empty refrigerant cylinder to the gauge opening of the discharge service valve and turning the discharge service valve all the way in to close the discharge line. Test for leaks. The compressor is then started which pumps the refrigerant into the cylinder instead of into the condenser. This operation is speeded up by keeping the cylinder cool with water, because the gases must condense in the cylinder in order that the refrigerant be pumped out. Do not let the unit pump oil as this will make the refrigerant unusable. Another method is to attach the cylinder line to the discharge service valve and then heat the unit until the refrigerant has evaporated from the unit and condensed in the cylinder. Small quantities of refrigerant are best discarded unless a means of distilling is available.

198. CARE OF THE SERVICE VALVES:

In all of the refrigerators equipped with service valves the valves must be leak-proof, and to obtain a leak-proof joint where the valve stem goes into the valve, various packings are used. These packings differ with different valve designs and when replacing them one must be sure the proper packing is used. Figure 159. The packing is made of asbestos, lead, and graphite.

Practically all the service valves up-to-date are equipped with steel stems, which have a tendency to rust and stick in the valve gland. A very good method of preventing this is to fill the valve body with refrigerant oil before replacing the plug each time the service valve is used. This oil, of course, should be the specified refrigerant oil for that machine. This precaution is especially recommended for moist, damp locations.

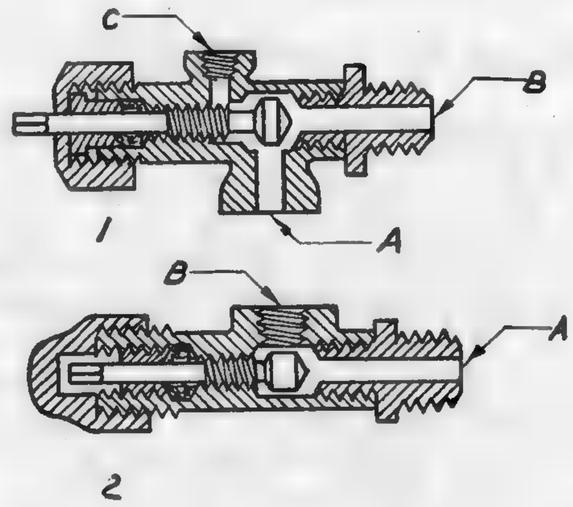


Fig. 159. Two typical service valve designs
1. A two-way valve
   A. Opening to compressor; B. To suction line; C. Opening for gauges
2. A one-way valve
   A. To liquid line; B. To liquid receiver

Before turning the valve stem to any position it is always advisable first to loosen the packing nut that is used as a seal around it. This can be done by turning the large packing nut a half turn or so. When turning the valve stem it is always best that a very steady pressure be applied to the wrench and that the wrench fit the stem well. If a sudden, jerky motion is used, or if the palm of the

hand is used to strike the wrench turning the valve stem, there is a likelihood that the stem will be twisted off, necessitating replacing the service valve.

In case a service valve is "frozen," it may be loosened by heating the body of the valve and tapping on the valve stem.

When cracking the valve, always use a fixed wrench, that is, not a ratchet wrench; this is so the valve may be quickly closed again if desired.

199. ADDING OIL TO THE SYSTEM:

When a compressor runs too warm and it is determined that it is due to a lack of refrigerant oil, there are two methods used to add oil. The most rapid method is to attach tubing to the low side, that is, to the suction service valve, and after purging the tubing immerse it in a glass jar nearly filled with refrigerant oil. Then run the compressor, and drawing a vacuum on the low side, open the suction service valve; the oil will be drawn into the crankcase. It is very important that some of the oil in the glass container be left in the container so that the filling tube is always immersed in the oil, otherwise air will be drawn into the system and cause trouble. The reason that a glass container is used is to enable the service man to observe how much oil has been added to the unit. It is a safe policy never to add more than a quarter of a pint of oil at a time to the smaller units.

The other method of adding oil to the system is to evacuate the crankcase; then equalize the pressures, remove the oil plug of the crankcase housing, and add the oil. Replace the oil plug and evacuate the compressor to the air or into a lye solution until all the air that may have seeped in is removed.

200. CLEANING THE INTERNAL REFRIGERATOR MECHANISMS:

A very good grade of gasoline and preferably a liquid called carbon tetrachloride should be used when cleaning the internal parts of a refrigerator mechanism, that is, all those parts that come in contact with the refrigerant itself. This is very important because any dirt allowed to remain in the system usually lodges on the flapper valves in the compressor, or the needle seat of the float valve or expansion valve causing considerable trouble.

201. MISCELLANEOUS SERVICE NOTES:

Pinching lines is a practice to be used in cases of emergency only. Many service men follow this practice needlessly and it only leads to future trouble. Almost all the systems are provided with sufficient valves to service them. One must remember that adding refrigerant to a system means that some of the oil in the system will be dissolved in the refrigerant; if a unit becomes noisy soon after the refrigerant has been added, some refrigerant oil should be added. Electric motors, when installed, should have soldered leads; the motor must be very carefully aligned with the compressor, and the belt tightness should be just right. (Paragraph 449.)

202. SERVICING THE SPARTON, GIBSON, AND TRUKOLD:

As explained in Chapter V the Sparton and Gibson refrigerators are mechanical refrigerators which, instead of being equipped with the usual three service valves, have only low side and high side pressure testing valves. Also, the refrigerator mechanisms themselves are not furnished with valves,

but have what one might call a valve attachment located in the mechanisms. The service man is furnished with a service valve which threads on to this valve attachment; it enables charging or discharging the mechanism and also checking the operating pressures.

The low side valve is located where the suction line goes into the compressor and the high side valve is located on the receiver tank. All that is necessary for the service man to do is to thread the service valve attachment to the valve body tightly; then turn the valve stem which has entered the slot of the plug in the valve body. Revolve the valve

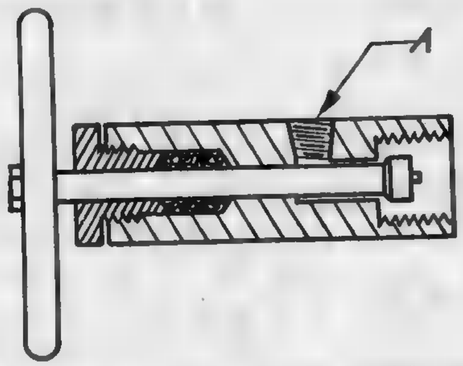


Fig. 160. A servicing valve attachment used on semi-hermetic or hermetic units
A. Opening for a gauge

stem a turn or two to the left. This enables one to admit or discharge refrigerant, or to check the operating pressures. This valve attachment is fitted with gauge openings. Figure 160.

Almost any point of disorder in the Sparton refrigerator unit may be ascertained by the use of the vacuum compound gauge and the pressure gauge. The valve mechanism is used for attaching these gauges. Valve mechanisms and gauges should always be carried by every service man. By proper use of these gauges, guess work is eliminated as they

indicate immediately what is taking place in the refrigerating system.

To determine the low side pressure reading, always pull the defrosting switch out and wait at least ten minutes until the pressure builds up in the low side line. No air can then be drawn into the system as you connect the gauge.

Warning. Since there is always a vacuum or suction in the low side line when the unit is in operation and for a period of time after the unit is shut off, it is an easy matter for air to enter the system when attaching the low side vacuum compound gauge if the unit is running. Air in the system will in time cause the unit to become inoperative.

To connect the vacuum compound gauge, first remove the brass cap from the valve on the compressor, and revolve the stem in the valve mechanism all the way to the left until it stops; then attach the valve mechanism to the suction valve on the compressor. Connect the flare nut on the brass tubing, running from the vacuum compound gauge, to the valve mechanism fitting. Revolve the stem of charging valve mechanism to the right until it seats in the slot of suction valve plug. Then turn to the left two turns which is sufficient to allow pressure from the compressor to register on the gauge. Always crack the flare nut that fastens the tubing to the gauge in order to remove any moisture that may have accumulated in the tubing.

With the unit still shut off, test for SO_2 leaks with a swab saturated with 26 per cent of aqua-ammonia. If there is a leak, a white smoke will be noticed as the swab is passed by the point of the leak.

When testing for high side head pressure, follow procedure for attaching valve mechanism.

The pressure gauge valve mechanism should be attached to the charging valve on the top of the liquid receiver. There is a different head pressure for each degree surrounding the

unit. The lower the room temperature, the lower the head pressure. To find the correct head pressure, determine the room temperature surrounding the cabinet and then consult the sulphur dioxide "Condensing Pressure-Temperature Chart," Figure 309. Gauge readings should indicate a pressure corresponding to the SO_2 line on the chart to be normal.

Low side back pressure will affect head pressure. Care should be taken to be positive that the expansion valve is set to maintain a low side back pressure of a 5-inch vacuum before head pressure reading is taken. If head pressure reading exceeds normal condensing pressure, shown in chart, it is an indication of air in the system, in which case with the unit running, crack the flare nut attached to the pressure gauge several times at intervals of a few minutes, permitting any air in the system to escape.

203. SERVICING THE NORGE:

The Norge is a completely serviceable refrigerator using a rotary compressor. It differs in servicing from the typical compressor installations only in two ways. Since it uses a rotary compressor, a check valve must be put into the compressor to prevent a backing-up of the oil into the cooling unit when the compressor is idle. This check valve must necessarily be in very good condition and absolutely leak-proof or one of the division points between the high and low pressure side will be broken down and the refrigerator will not operate satisfactorily. This check valve is incorporated in the suction service valve. The suction and liquid lines from the condensing unit to the cooling unit are placed along the left side door trim in order that the unit may be removed as a complete whole when the necessity arises.

Their most popular cooling unit design is the flooded type using a float valve. The float is the open pan type and the header on the evaporator is brazed on so that the pan can-

not be removed. They use the cartridge type needle valve, Figure 161, and this may be replaced by removing the liquid line fitting on the head of the cooling unit evaporator. Figure 96 illustrates the Norge cartridge needle float valve. When replacing a needle cartridge, do not reassemble the apparatus until you are sure that the needle is clipped into the correct position on the float. This may be determined by a clicking sound being heard when the needle slips into place. The test for a leaky needle valve in the cooling unit is the same as that for the typical apparatus, and the efficiency of the compressor may be detected by attempting to draw a

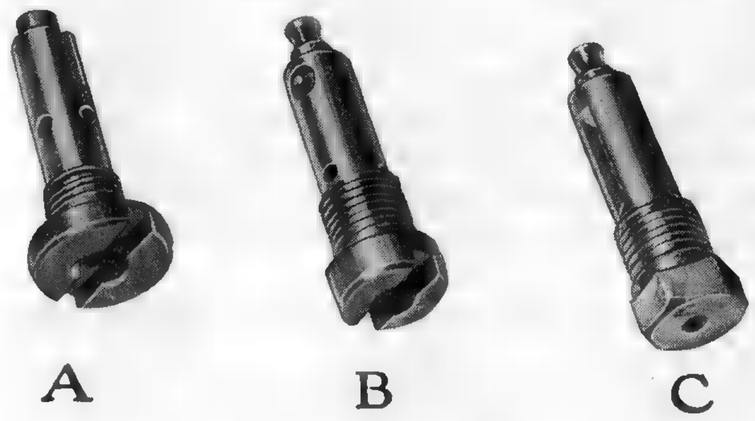


Fig. 161. Three different cartridge type float needle valves
(Courtesy of: Norge Corporation)

vacuum after closing the suction line valve and the service valve. The system uses sulphur dioxide; therefore the ammonia swab is used for testing for leaks.

The sylphon seal located where the compressor shaft goes through the compressor housing is on the high pressure side and is also submerged in the oil. Therefore, the first indication of a sylphon leak is that the compressor becomes oily at that end. The usual sulphur dioxide test, however, will also

indicate the leak. Both the crankshaft shoulder and the bellows are removable and, therefore, easily serviced.

If the spring which keeps the compressor blade up against the compressor rotor breaks, it may be detected by a clicking noise which is the result of the rotor hitting the blade every time it goes around. The motor control has the thermostat located in such a position that the housewife can change the refrigerator temperature if she so wishes. When removing the Norge compressor, one must purge the oil reservoir into a lye and water container. Figure 348. This reservoir is under high pressure; therefore there is some sulphur dioxide dissolved in the oil. To purge this gas, a purging line equipped with a needle shut-off valve and a check valve must be provided. Because the compound gauge connection is between the check valve and the compressor, the only test to give the compressor is to produce a steady non-fluctuating 30-inch vacuum against a 150-pounds per square inch head pressure.

204. SERVICING THE LEONARD AND THE KELVINATOR:

The 1932-35 Leonard and the 1933-35 Kelvinator use the high side float refrigerator mechanism. This does not alter the servicing except that there are two possible places where a dirty needle valve may give trouble. However, these possibilities are very remote. If the needle valve in the receiver tank should leak, it will cause too much pressure in the line between the receiver tank and the weight valve located in the cooling unit and will force it open, thereby destroying proper operation. The only way to repair this needle valve is to remove the refrigerant from the system.

The 1933-35 Kelvinator is so designed that the low pressure liquid line and the suction line are installed in the molding of the door, and the lines do not need to be disconnected to remove the complete system from the box.

205. SERVICING THE COLDSPOT:

The Coldspot is equipped with one service valve attachment on the low side. Figure 99. The attachment is made similar to the Sparton valve, but the attaching threads are male instead of female and instead of a screwdriver fitting, a square socket is used. This attachment permits the obtaining of the high side pressures when the unit is stopped. A seal squeak or leak may be remedied by stopping the compressor and removing the cover of the seal. Start the compressor and move the seal ring away from the seal surface a little. The pressure will flush the surface with oil, generally curing the trouble. A leaky expansion valve may sometimes be cured by flushing it. That is, turn the expansion valve all the way out and then, after waiting a few minutes, turn it back in fast to permit the rush of refrigerant to wash the orifice surfaces.

206. SERVICING THE GENERAL ELECTRIC MONITOR TOP.

A noisy unit may sometimes be remedied by putting extremely hot water in the cooling coils. This will force the oil up into the dome again. Oil bound cooling coils are also remedied this way. A stuck shut high side float may be remedied by putting a powerful electromagnet, A.C. or D.C. on the top of the float chamber. The float is made of steel and the magnetism will lift it from its seat.

207. SERVICING THE GRUNOW:

The new model Grunows use high side floats and have one gauge attachment on the high side float chamber. The

refrigerant (Carrene) is dispensed in cans because of its low pressures, and is poured into the system through this gauge opening. The float chamber is built to hold just the correct quantity of refrigerant used in the system. To charge the system, put an electromagnet on the bottom of the chamber holding the float down. Run the unit and heat all the parts except the float chamber. After the cooling coil is heated, open the gauge opening and if the refrigerant comes out, the charge is correct. If not, some must be poured in. To test for leaks, the condenser motor must be stopped and a cloth placed over the condensing unit while it is still running to allow it to warm up. This will bring up the pressure to 5-10 pounds per square inch and a halide torch may be used to test for leaks. A stuck shut float valve may be remedied by using the electromagnet to lift it up.

208. SERVICING THE ABSOPURE:

The Absopure units which were built in Detroit in the late twenties were methyl chloride units using a Detroit Lubricator expansion valve mounted on a brine tank cooling coil. In the older models the service valves were threaded into the compressor rather than bolted to it. This necessitated discharging the complete system, pinching the line between the condenser and the compressor, or leaving the cylinder head, in which the discharge service valve was threaded, on the unit when overhauling the compressor. The compressor had an eccentric for a crankshaft. This was made of cast-iron and threaded on the shaft. These threads were right hand and, therefore, the compressor may only be run clockwise looking at the flywheel. A large nut was used to hold the seal against the housing. The flywheel was mounted on the shaft by means of a taper, but no Woodruff key was used.

The flywheels used on these machines were balanced in

themselves and no unbalance of the flywheel was used to balance the crank throw of the compressor. It is important that these flywheels be kept in balance or the machine will vibrate excessively.

209. SERVICING THE ELECTROLUX:

The two most important observations to be made in servicing the Electrolux gas-fired refrigerator are to determine that the gas and the water furnished the refrigerator are supplied in the correct amounts. The amount of gas fed to the refrigerator may be checked by the size of the flame and may be adjusted by the use of the automatic temperature-controlled gas valve which has a manual adjustment on it. The flue must be kept perfectly clean to allow a good transfer of heat. Brushes and scrapers are used for cleaning the flue. The air inlet screen on the burner must be kept perfectly clean.

The water supply has an automatic valve located on the exhaust end of the condenser, and the only precaution to be observed here is that the outlet temperature of the water does not exceed 90°F. These valves are explained in detail in Chapter VII.

210. SERVICING THE FARADAY:

The Faraday water-control valve must meet the same requirements as the Electrolux water-control valve. That is, the outlet temperature of the water must not exceed 90°F. The gas supplied to the refrigerator is intermittent in its flow, and the only precaution and test is to see that its pressure is kept constant and that it does not exceed two inches of water column pressure. A simple U-tube manometer may be used to check this.

211. LOCATING TROUBLES:

The methods of testing used to locate the sources of trouble are all based on the operating principles of the mechanism. By checking the pressures, temperatures, running time, etc., one is soon able to isolate or pick out that part of the system which is giving trouble. Naturally the service man must have a thorough knoweldge of the fundamentals of refrigeration and of the cycles before he can become a reliable and competent trouble tracer and repairer. It is obvious that one must locate the trouble in a refrigerator mechanism before dismantling it in order to keep the cost of servicing at a minimum and to make sure that the repair work is going to enable proper functioning of the mechanism after assembly.

The methods of locating troubles naturally vary with the type of the system, that is, with the direct expansion, with the low side float, or with the high side float. The call for service should give the first indication of what the trouble will be; the owner will probably say that there is an odor, that it costs too much to operate it, that it is not freezing but is running continuously, or it is freezing but running continuously, etc. From these trouble calls the service man may usually get a pointer as to what the trouble is, but he should always verify these statements by checking over the refrigerator before attempting any trouble shooting or service work. The method of trouble tracing is best learned and is best adapted to practical work by first classifying the type of service call and then determining what caused the trouble named in the service call. Therefore, the following trouble shooting pointers have been prepared to help the service man. Naturally, it is impossible to give every detail, but once the service man learns the method of trouble tracing he should have no difficulty. A service man should check

all of the following things in a refrigerating mechanism before coming to a conclusion as to the trouble.

1. The low side pressure
2. The high side pressure
3. The temperature of the cooling unit
4. The temperatures of the liquid line and of the suction line
5. The sound of the refrigerant control (float valve or expansion valve)
6. The running time of the mechanism
7. The probability of leaks
8. Noise.

212. LITTLE OR NO REFRIGERATION AND THE UNIT RUNS CONTINUOUSLY:

A. Direct Expansion System.

If the unit has lost all the refrigerant, there is naturally no refrigeration; to test for this, install the gauges and determine the evaporating or low side pressure. If this pressure is correct, the only possible trouble is that the unit has little or no refrigerant. If the compound gauge indicates a high vacuum, 20 inches or more, it means that the expansion valve is either so adjusted that it draws this vacuum, it is frozen closed, or it has a clogged screen. A high vacuum may also be caused by a suction service valve being shut off or by a clogged or restricted suction line fitting. In either case it is not allowing refrigerant to flow through it, and there will be no refrigerant on the low side which naturally gives continuous running with little or no refrigeration on a temperature controlled unit. This trouble will not be encountered on a pressure-controlled unit.

If the compound pressure gauge shows a high pressure on

the low side, that is, a pressure which will not allow the refrigerant to evaporate at a low temperature, the trouble may be a stuck-open expansion valve or one that is out of adjustment. This trouble will have an additional indication of a frosted or sweating suction line because it simply means that the refrigerant is going into the low side too fast and will flood both the cooling unit and the suction line. This high pressure may also be due to an inefficient compressor which may be checked as described in Paragraph 175. Of course, this trouble may also be due to a broken belt or a sheared flywheel key, but these will naturally be detected on the first inspection of the unit. If the expansion valve is stuck open, it may be due to dirt on the needle. To remedy, one may flush the valve by turning the adjusting screw in and then alternately opening and closing the liquid receiver service valve, causing surges of liquid past the expansion valve needle, thereby cleaning it.

B. The Low Pressure Side Float System (Flooded).

If the compound gauge indicates a high vacuum, it may be due either to a frozen needle valve, or a restricted suction or liquid line (clogged screen). To determine whether it is a frozen needle valve or a lack of refrigerant:

1. Stop the compressor after installing the gauges and notice the action of the compound gauge. If it creeps up very rapidly to almost the pressure on the high pressure side, it indicates that the needle valve is open; therefore, there is a lack of refrigerant; but if the pressures do not tend to equalize, it means that the needle valve is stuck closed or that the suction line or liquid line has become clogged. If the needle is stuck closed, a sudden jar will loosen it. Use a rubber hammer or shake the cooling unit. In case there is a lack of refrigerant it is best to remove

all of it; then put back into the system a specified quantity as recommended by the manufacturers of the equipment. See Chapter XIX.

2. If the compound gauge indicates a high pressure, it may be due to a slight lack of refrigerant, a stuck-open needle valve, or an inefficient compressor.

It is best first to eliminate the compressor by testing its efficiency and then determine whether there is a stuck-open needle valve or a lack of refrigerant. To do this, flush the needle valve by shutting off the liquid receiver service valve and running the unit for a few minutes. Then open the liquid receiver service valve very rapidly. Allow a rapid flow of refrigerant through the needle valve orifice which may wash out any dirt particles on the needle valve seat. If this does not cure the trouble, charge the refrigerator with some refrigerant and see if that will cure the trouble. If this does not, it means that the cooling unit must be dismantled.

A rather accurate check as to whether it is a lack of refrigerant or a stuck-open needle valve is the frosting of the suction line. If the line frosts back excessively it means that there is too much refrigerant in the cooling unit, leaky needle, etc. If the suction pressure is too high, this indicates an open needle valve. To check for an open needle valve the compound gauge will creep up rapidly as soon as the unit is stopped because the high pressure tends to equalize rapidly through the needle valve. A lack of refrigerant will not frost the suction line. Both of these troubles will give a continuous hissing sound in the cooling unit. Of course, this may also mean an inefficient compressor, but that is easily checked.

Short cycling of the mechanism, that is, the unit shutting down for only a minute or two at a time is indicative of a

rapid pressure rise in the low side. This is particularly true on the older units which use a pressure control.

C. High Pressure Side Float (Flooded).

If the compound gauge indicates a very low pressure, it means a lack of refrigerant or a stuck-shut float valve. The lack of refrigerant may be checked by watching the compound gauge pressure when the unit shuts down, for if the pressure creeps up gradually it means that there is a lack of refrigerant; but if the pressure gauge maintains a low pressure, it means that the valve is stuck-shut. If the compound gauge indicates a high evaporator pressure, it is due to a leaky float valve or an inefficient compressor. The compressor may be easily checked for inefficiency. Another test is to shake the float chamber and if it is a stuck-shut needle, this will break it loose. A clogged screen will also give the above results. A high head pressure will indicate air in the system or restricted cooling, whereas a lack of refrigerant will give a head pressure below normal. A high side float system must be purged occasionally because a high head pressure, due to air in the system, hinders correct operation of the float. The head pressure of the unit may be easily checked as follows: for an air-cooled unit the refrigerant will be 30°F.-35°F. warmer than the room. By using the refrigerant chart in Chapter XVI, the correct pressure may be determined. Also, sulphur dioxide systems have a head pressure corresponding approximately to the room temperature, i.e., a 75°F. room will make a unit have a 75 pounds per square inch head pressure.

An excessively high head pressure may cause the high side float to collapse. This causes the float to lose its buoyancy and the high side float needle will tend to remain closed at all times. Such a trouble will be indicated by too low a low side pressure and a complete lack of refrigeration.

213. NO REFRIGERATION; THE UNIT DOES NOT RUN AT ALL:

The first trouble, and probably the most frequent one, is a blown fuse somewhere in the circuit, which may be easily checked with a trouble lamp and repaired by inserting a new fuse. Also, the power may be shut off, which may be easily checked by using a trouble light; or the motor may be burned out. An ineffective temperature control, such as a leaky power element, which may be checked as described in Paragraph 100, is also a cause of the motor not starting. On those units using a low pressure control for the motor, the trouble may be due to a stuck-shut needle valve in the refrigerant circuit which would naturally draw a very high vacuum on the suction side. This pressure will not creep up again as it would normally, due to a lack of refrigerant in the low pressure side of the system causing the pressure control to keep the electric motor disconnected continuously.

214. MOTOR RUNNING CONTINUOUSLY AND NORMAL OR TOO MUCH REFRIGERATION:

This trouble is due, usually, to a faulty temperature motor control which will not cut out at the correct temperature. It must be remembered that there is a correlation between the temperature control cut-out point and the evaporating pressure on the low side. If the temperature control is adjusted to cut out at a temperature corresponding to a pressure lower than the evaporating pressure, the thermostat cannot stop the electric motor.

A. Direct Expansion System.

If there is an undercharge of refrigerant in the system there may be just enough to fill the evaporator or cooling unit partially, but not enough to extend to the temperature

control cut-out point and shut down the unit. In this way one may get normal refrigeration, but the unit will never shut down. This trouble may be detected by checking the frost accumulations on the exhaust tubing of the cooling unit and seeing if it reaches as far as the temperature control, and is also indicated by a warm liquid receiver and liquid line.

Trouble may also be caused by an overcharge of refrigerant or air in the condenser, because excessive head pressures decrease the efficiency of the compressor to such an extent that continuous operation is the result. A leaky expansion valve will sometimes give normal refrigeration, but will not allow the pressure to drop to such an extent that the temperature control will cut out the motor. An improperly adjusted expansion valve will also give this trouble. This will result in a frosted suction line, an above normal and fluctuating low side pressure. An inefficient compressor may also be the cause. All these may be checked by the use of the gauges. The expansion valve troubles and the compressor troubles may be checked as in service call.

B. Low Pressure Side Float (Flooded).

An undercharge or overcharge of refrigerant will give the above trouble. An inefficient compressor, excessive head pressure due to air in the system, a restricted condenser, an overcharge of refrigerant, or a suction pressure which is not low enough to cut out the temperature control may give refrigeration but run continuously. This may also be due to a leaky needle valve or lack of refrigerant.

A leaky needle will cause a frost back and it will hiss continuously. A lack of refrigerant will hiss continuously, but it will never more than sweat back. Also the liquid line will be warmer than normal.

C. High Pressure Side Float (Flooded).

This system is very sensitive to the quantity of refrigerant in the system. Any variation in this quantity will result in faulty refrigeration. Too little refrigerant will result in lack of sufficient refrigeration and too low a suction pressure. Too much refrigerant will result in a flooded unit, a too high suction pressure, and a frosting of the suction line. An inefficient compressor will result in insufficient refrigeration.

215. SHORT CYCLING:

By short cycling is meant running and stopping, each for only a few minutes at a time. This trouble is due principally to a rapid pressure rise on the low side of the system and may come from an inefficient compressor or a leak at the float valve or expansion valve. This will also cause a frosting of the suction line. Occasionally, in those systems which use a brine tank, a loss of the brine will cause a short cycle because of the rapid heat interchange. A temperature control which is out of adjustment, that is, one with a very small differential will also cause a short cycle.

If the refrigerator has a pressure motor control, short cycling may be caused by either a leak in the float valve or poorly seated compressor valves. In either case the pressure on the low side will rise rapidly causing the motor to start.

Machines equipped with a high side safety control will sometimes short cycle if the condensing pressure becomes too high because of a high condensing temperature.

216. A NOISY UNIT:

There are three sources of noise: the compressor, the electric motor, and the mounting of the complete condensing

unit. A compressor is noisy when the valves, the piston pin, the connecting rod, and piston have become worn, see Paragraph 175, or if it pumps oil. Sometimes when the compressor gets very warm, it will develop knocks which are usually rather hard to remedy. The metal shaft seal used on most of the conventional compressors occasionally becomes very noisy and emits a very shrill squeak. This is indicative of a lack of oil, at the seal, and, if not remedied immediately, will soon score the seal and naturally cause a leak at that point.

The electric motor will give noise trouble due to a fan roar, squeaky bearings, or an armature rumble. Occasionally, if the motor is loaded too much the repulsion start does not cut out and will result in a continuous noisy operation. If this trouble is allowed to continue, the motor will burn out in a very short time.

End play in an electric motor is necessary, but an excess will make a dull knock.

A belt noise may be due to a very dry belt or pulleys that are out of line. It may be remedied by using soap or some other substance recommended for belts and by lining up the pulleys. *Do not use oil.* Sometimes the whole machine unit will vibrate excessively, producing a rumbling sound as the unit runs and shaking the cabinet disagreeably. This is due to improper mounting, such as the wrong rubber suspension or spring suspension; it may be due to not enough play in the suction and liquid lines, or some obstruction may have been put in the compartment which destroys the action of the shock and the noise absorbing spring mounting of the condensing unit.

An excessive head pressure will make a unit vibrate more than normal.

A badly worn needle or seat in an expansion valve will

sometimes make a chattering noise while the unit is in operation.

217. IMPROPER REFRIGERATION BUT THE UNIT FREEZES ICE CUBES:

When the box temperature is over 50°F. and the unit still will form ice cubes, the trouble is either in the excessive frost accumulation on the cooling unit or restricted air circulation in the box. This trouble is also indicative of a poorly insulated box, but this is very seldom the case, due to modern insulation practice. If there is an excessive frost accumulation on the cooling unit, remove as recommended in Paragraph 146; if it is a restricted box circulation follow the rules as set forth in Paragraph 140. It is possible to crowd the refrigerator cabinet with food and at the same time leave the drip pan below the cooling unit. The box will not operate successfully under these conditions and it is very important that this be thoroughly understood by the owner.

218. ABSORPTION SYSTEM TROUBLES:

Practically the only troubles encountered in the absorption system refrigerators are the following: the temperature of the box is too cold, or there is little or no refrigeration at all. The kerosene-fired units must have a thoroughly dry burner and kerosene. Moisture will cause the burning kerosene to give an odor.

219. TEMPERATURE OF THE REFRIGERATOR TOO COLD:

In the intermittent cycle type refrigerator such as the Faraday, too cold a temperature usually results from the following:

First, temperature control dial set too cold which may be the case when the customer has not been properly instructed in its use.

Secondly, the temperature of the cooling unit may be lower than that indicated by the temperature control dial setting. This may be caused either by the temperature control chain spring having too much slack in the No. 4 position or it may be that the temperature control is out of adjustment.

A time temperature graph should be taken of such a machine which will tell much more clearly what is wrong. See Chapter XVII.

220. LITTLE OR NO REFRIGERATION:

Little or no refrigeration may be due to an overloaded box, but if this is not the trouble it may be due to one of the following: in the continuous cycle, little or no refrigeration is due principally to either improper condensing temperatures or little or no heating of the generating unit. If the water supply has been stopped, or if the line has become clogged, or if the valve has gone out of adjustment, there is a possibility that the condensing temperatures instead of being around 85-95°F. will be much higher causing a very inefficient operation of the unit, resulting in little or no refrigeration. Check the exhaust water temperature with a thermometer and then clean the line or adjust the valves until proper pressures and temperatures are obtained. Furthermore, if improper water is used for cooling purposes, it may eventually coat the condenser tube pipes with an insulation resulting in a very poor heat transfer giving the same trouble. Replacement is the only remedy. The water supply should have been carefully investigated before the refrigerator was installed.

If the gas supply has been shut off or if the line has become clogged, resulting in a very small consumption of gas, there is naturally little or no refrigeration. This trouble may be traced by checking the gas pressures at the burner. Two other reasons for poor heat transfer or poor heating of the generating unit are: a restricted gas flue or an insulated gas flue. After a certain period of use the body of the generator becomes coated with a soot deposit, preventing a rapid transfer of heat from the gas flame to the generator body and this soot deposit should be removed periodically (1-2 months) to insure proper refrigeration and to reduce the cost of the gas consumption. When scraping the flue of a generator or when removing the soot from any surface of the generator, considerable care should be taken to prevent any injury to the surface. All of the gas-fired and kerosene-fired refrigerators are equipped with a flue to direct the hot gases around and away from the generating unit. Occasionally these flues are clogged by placing the refrigerator too close to the wall, by placing objects over the opening, or by having some obstruction fall into it. These flues must be kept clean to insure proper functioning of the refrigerator. An Electrolux unit which has not been used for a period of time may refuse to freeze when started. To remedy this trouble, remove the unit from the cabinet and invert it for approximately ½ to 1 hour. Right the unit and install it in the cabinet.

221. REVIEW QUESTIONS:

The answers to the following questions may be found on page 817.

1. What trouble is indicated by a hot liquid line?
2. What is the size of the service valve stem wrench?
3. Why must dry air be used to test the controls for leaks?
4. What does a pounding sound in the compressor, when a vacuum is being produced, indicate?

5. Give several reasons why a gauge installation must be tested for leaks.
6. Why must a leak testing torch be charged and pumped up out in the open air and not in the same room in which a refrigerator is located?
7. What are service valve packings made of?
8. List the procedure followed in lapping an exhaust valve seat.
9. What trouble results in a 110 pounds per square inch head pressure in an air-cooled sulphur dioxide system?
10. A frosted suction line with an excessive low side pressure is the indication of what trouble?
11. In what part of the system is the compound gauge usually installed?
12. In what part of the system is the high pressure gauge usually installed?
13. Why must the pressures be balanced before a system is opened?
14. What should the average low side pressure be for sulphur dioxide?
15. What should the average high side pressure be for sulphur dioxide operating in a room temperature of 85°F?
16. What precautions should be observed when filling service cylinders with refrigerants?
17. Why may discharge service valves and suction service valves be called two-way valves?
18. What four things cause trouble in an expansion valve?
19. What difficulties may result if moisture is allowed to collect on the outside of the expansion valve bellows?
20. How should a low side float ball be tested for leaks?
21. Explain how to test for sulphur dioxide leaks.
22. Explain how to test for methyl chloride leaks.

23. What indicates the presence of air in a condenser?
24. Name two methods of adding oil to a system.
25. In case the compressor crankcase oil is on the high side, what special precautions must be taken when removing a compressor?

CHAPTER XII

SERVICE TOOLS AND THE REFRIGERATOR SERVICE SHOP

Inasmuch as the minute details of all refrigeration work are so important for the safe and satisfactory operation of the refrigeration mechanisms, a careful study must be made of the techniques of performing common operations. Careless, inaccurate, slip-shod work has no place in refrigeration. A good service man knows this and is therefore a conscientious and expert workman. It is the aim of this chapter to give the necessary foundation in the use of tools and the use of refrigeration shop equipment required for the successful installation and handling of refrigeration equipment.

222. TUBING:

The tubing used in all domestic refrigeration work, with the exception of some absorption machines, is specially annealed copper tubing. The purpose of the annealing is to make the copper flexible and to adapt the tubing for flaring. The tubing is also "dehydrated" to free it of moisture. This drying is done by the manufacturer and the tubing is then sealed at the ends by pinching and soldering. The tubing may be obtained in sizes from 3/16 inch to 5/8 inch in outside diameter and in 50 and 100 feet lengths, although some companies furnish it in as low as 25 feet lengths. When ordering tubing be sure that the dehydrated annealed and seamless type is specified. The standard wall thickness for soft copper tubing is .035". Hard drawn copper tubing, which comes in straight lengths rather than in rolls, is used in many commercial and air conditioning installations particularly in installations requiring tubing sizes over ½ inch.

Fittings used with this tubing are streamline and hard soldered. The wall thickness varies with the diameter. See Paragraph 440 for a table of tubing sizes and wall thickness. Hard drawn tubing is either capped or plugged when purchased to keep it clean and dry.

REFRIGERATION FITTINGS (FLARED TUBE)

Sizes are for Outside Diameter of Tubing

Name and Description	1/4"	5/16"	3/8"	7/16"	1/2"	5/8"
Nut Forged	x	x	x	x	x	x
Union (Threads same size)	x	x	x	x	x	x
Half Union (1/8" Pipe)	x	x				
Half Union (1/4" Pipe)	x	x	x	x		
Half Union (3/8" Pipe)					x	
Half Union (1/2" Pipe)						x
Elbow	x	x	x	x	x	x
Elbow (One 1/8" Pipe)	x	x				
Elbow (One 1/4" Pipe)	x	x	x	x		
Elbow (One 3/8" Pipe)					x	
Elbow (One 1/2" Pipe)						x
Tee (Threads same size)	x	x	x	x	x	x
Tee (One 1/8" Pipe)	x	x				
Tee (One 1/4" Pipe)			x	x		
Tee (One 3/8" Pipe)					x	
Tee (One 1/2" Pipe)						x
Cross	x	x	x	x	x	x
Flared Tube Sealing Plug	x	x	x	x	x	x
Flared Tube Sealing Cap		x	■	x	x	x
Flared Tube Copper Seal Cap	x	x	x	x	x	x
Union (Reducing)	5/16–1/4	3/8–1/4	1/2–1/4	1/2–3/8		
Elbow (Reducing)	5/16–1/4	3/8–1/4	1/2–1/4	1/2–3/8	5/8–1/2	
Tee (Reducing)	5/16–1/4	3/8–1/4	1/2–1/4	1/2–3/8	5/8–1/2	

Fig. 162. Popular refrigeration fittings using pipe and S.A.E. threads

223. TUBING FITTINGS:

There have been many different fitting designs on the market but the accepted standard for refrigeration fittings is a forged fitting using either pipe thread or Society of Automotive Engineers (S.A.E.) National Fine thread. Figure 162. Wherever tubing is attached to a fitting the flared

type of seal is usually used. This practice is conventional throughout the industry in the smaller units. A later trend is a soldered connection between the fitting and tubing using a brass sleeve soldered to the tubing. Figure 163. The correct method of installing tubing is to bend it in such a way that there is no extra strain on the tubing when installed.

224. CUTTING AND FLARING TUBING:

The construction of the flare is also of importance. It is

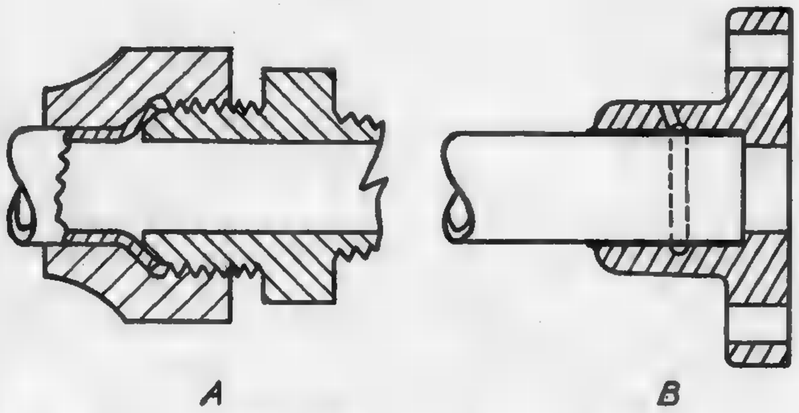


Fig. 163. The two standard methods of joining tubing to fittings
A. Threaded and flanged; B. Soldered

necessary to use the proper tools and these tools must be in good condition to get leak proof flares. Figure 164.

To cut the tubing a hack saw or a tube cutter may be used. The tube cutter is to be preferred. If a saw is to be used, a wave set blade of 32 teeth per inch should be used. It is important that no filings or chips of any kind be allowed to enter the tubing. In cutting tubing with a hack saw, pinch the tubing tightly together just past where the cut is to be made. Hold the tubing in such a manner that chips will not

fall into the section that is to be immediately used. Pinching the tube eliminates the danger of chips entering the tubing that is not to be immediately used. It also seals the tubing against moisture and protects it for further use.

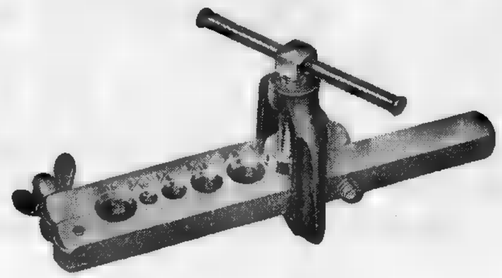


Fig. 164. A tube flaring tool
(Courtesy of: The Imperial Brass Manufacturing Company)

After the tubing has been cut, its ends must be scraped or reamed with a pointed tool to remove any sharp burrs on the end of the tubing. Some tube cutters have one of these tools built into them. Figure 165. The tubing should then be straightened to eliminate an off-center flare. To get a flare of the correct size, the tubing must be inserted into the flaring tool so that it extends above the surface of the tool one-

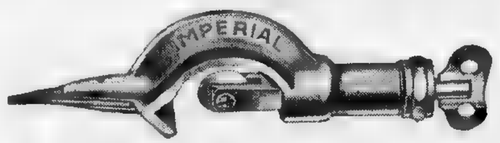


Fig. 165. A tube cutter and reamer
(Courtesy of: The Imperial Brass Manufacturing Company)

third of that distance which is equal to the depth of the flare. Figure 166. The spinner may now be tightened down on the tubing end. The tubing should be worked gradually into a flare, that is, an oscillating motion should be used. First

put a drop or two of the correct *refrigerant oil* on the tubing end; then tighten the spinner one-half or three-quarters of a turn and back it approximately one-quarter of a turn. Advance it another three-quarters of a turn and again back it one-quarter of a turn. In this way a tubing flare of accurate contour is made with no danger of the tubing cracking.

If the service man prefers, he may, when making the flare, spin the flare not quite to its full contour but only shape it to about seven-eighths of its full position so that when the tubing is tightened into its fitting the flare will assume the shape of the fitting. Under no circumstances tighten up the

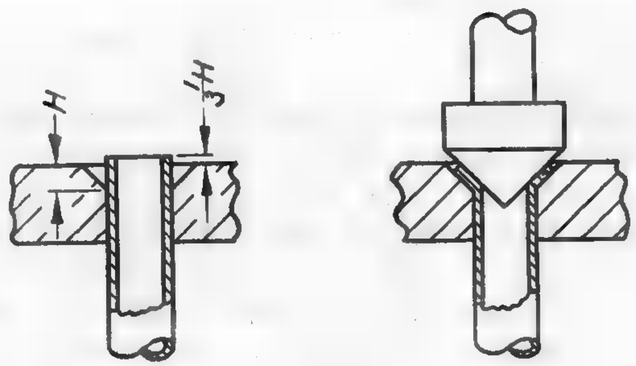


Fig. 166. The correct method of clamping the tubing in the anvil and flaring the tube

spinning tool too much because this will thin the wall of the tubing at the flare and weaken it considerably. It is needless to say that when making a flare, the first step is to put the nut on the tube before the flare is made because it cannot be installed on the tubing after the tube has been flared. This flare is called the single flare and is by far the most popular, but certain companies specify what they call a double flare which means that the part of the tubing which forms the flare is made of double thickness. This flare is recommended

for only large size tubing (5/16 inch and over) and cannot be made very well on the smaller tubing. However, it does make a stronger joint and, if possible, is to be used on the tubing that is used on the commercial models. This flare is made using a double flaring tool, that is, one tool works the tubing into a bullet-like nose, and the other tool bends the tubing in and into the flare as described above, making the flare of double thickness. Figure 167.

The punch and block method of a single flaring tubing has long been used in refrigeration work and is still used as the standard method by a large company. If a flare splits

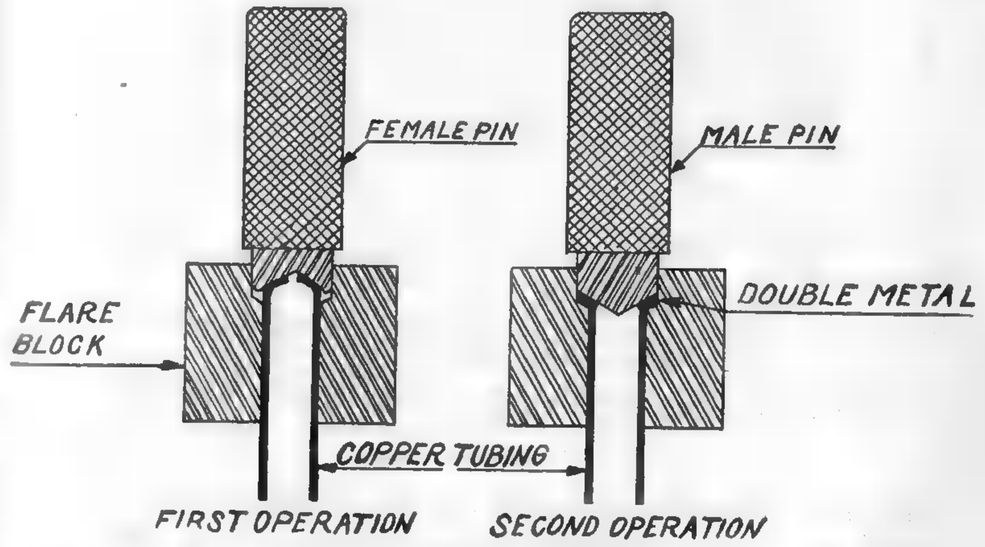


Fig. 167. The punch method of forming the double shouldered flare
(Courtesy of: Copeland Sales Company)

when being made, it may be due to the age of the tubing. Old tubing becomes brittle after a certain period of use and cannot be flared. A remedy is to anneal the tubing by heating it to a cherry red and quenching it in water.

225. BENDING:

It takes considerable practice to become competent in bending tubing. For the smaller size tubing such as is used in domestic models it is not necessary to use special tools to do the bending. However, a much neater job and a much more satisfactory one is obtainable by using special tools. As mentioned before, the tubing should be so bent that it does not make any strain on the fittings after it is installed. Another important thing is that the tubing at the bend should not be reduced in cross-sectional area, that is, be very careful when

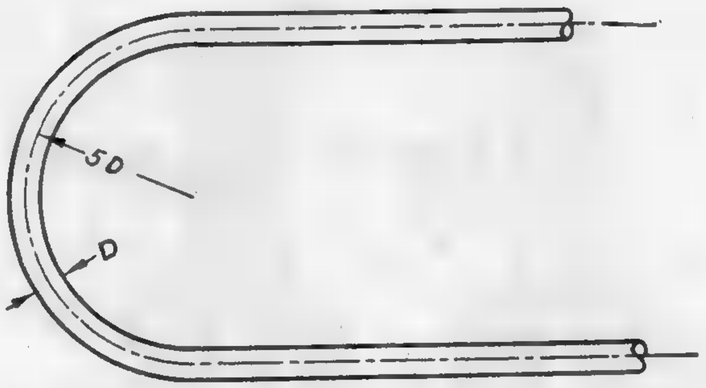


Fig. 168. The minimum safe bending radius for tubing

bending the tubing to maintain the roundness of the tubing and not allow it to flatten out or buckle. It is always wise to bend the tubing into as large a radius as possible because that reduces the amount of flattening of the tubing to a minimum and it is also easier to bend it that way. The minimum radius in which tubing may be bent is between five and ten times the diameter of the tubing. Figure 168. Tube bending should be done quite slowly and carefully. Do not try to make the complete bend in one operation, but bend the tubing

gradually so that it may not be ruptured by too sudden a stress.

Some special tools which have been used to facilitate the

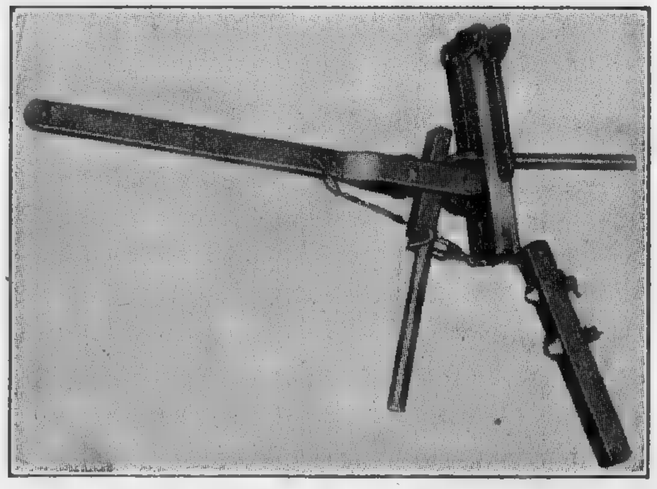


Fig. 169. A tube bending tool which prevents buckling of the tube while it is being bent
(Courtesy of: Electrolux Refrigerator Sales, Incorporated)

bending operations are a round block or a short-section of large piping for hand bending; to obtain very accurate work, bending tools may be purchased from manufacturers. Figure 169 shows a very convenient tool because in addition to bending tubing it has facilities for flaring. An inexpensive coil spring bending tool which is easily carried in a kit and insures against tube buckling is illustrated in Figure

Fig. 170. A coil spring tool for bending tubing
(Courtesy of: The Imperial Brass Manufacturing Company)

170. It comes in all sizes and is made for external and internal use. The internal spring is for use near the ends of the tubing or flared tubing while the external is best used in the middle of long lengths of tubing. A ¼-inch O.D. tube bending spring may be used as an internal spring for ½-inch O.D. tubing.

226. SOFT SOLDERING:

Soldering is becoming more and more a regular service operation because in simplifying the joints the manufacturers have fallen back on the simple soldered connection. Soldering may be classed as an art, for it is only after very diligent study and application of soldering theory that real soldering results may be obtained. A 50 per cent tin and 50 per cent lead solder is usually satisfactory for soft soldering except on cooling coils and their connections. However solders containing as much as 95 per cent lead are now being recommended for refrigeration work on cooling coils subjected to temperatures below 30°F. Fundamentally, in order to solder; (1) the surfaces to be soldered must be very clean, (2) a good flux must be used, (3) and a source of heat of sufficient quantity must be on hand. Brass parts, copper tubing, fittings, and the containers, such as the cooling unit of the refrigerator, are very easily soldered and this facilitates the work of the service man.

A portable torch is the only practical tool to use for heating surfaces to be soldered. The gas that is recommended for this type of torch is either gasoline or Prest-O-Lite. The flux recommended for this type of work is that which has no corrosive properties and one of these is the flux made of alcohol and resin. If an acid flux is used in this work, it tends to corrode the fittings and makes them unsightly and hard to work on later.

Soldering coppers are frequently used to perform some of the lighter soldering tasks. These coppers come in sizes from 1 to 4 lb. The copper must have a thin coating solder on the surface of the point. This "tinning" of the copper is accomplished as follows:

1. Remove the oxide from the point with a smooth file or sandpaper
2. Heat the copper
3. Sandpaper the point of the copper
4. Immerse the point in some flux
5. Rub the point of the copper in some solder; place in the hollow of a salammoniac block

Wire solder is usually the most convenient to use because of the difficulty of getting at the soldering surfaces and the ease of application of the wire solder. To clean the surfaces previous to the soldering a dry abrasive should be used, such as sandpaper. Do not use emery cloth or emery paper on the surface under any conditions because the oil in the emery will cling to the surface. While soldering, a helpful procedure is to "wipe" the surfaces one is soldering after putting some solder on them; use a cloth, a brush, or the solder wire itself. This will remove the dirt and will tin the surfaces.

227. REPAIRING THREADS:

Occasionally the threads of a fitting or fixture may become worn to such an extent that they will not remain leak-proof, especially pipe threads. A very convenient and rapid remedy of this is to coat the threads with solder and then knock the excess solder off while still warm. The threads will then be coated with a thin film which will usually remedy the trouble.

228. SILVER SOLDERING AND BRAZING:

To obtain rigidity and strength, manufacturers are tending to use more and more silver soldered joints. The same rules apply to this kind of soldering as to the soft soldering, but a torch *must* be used and a special flux is needed. Hard solder is either a silver alloy or an alloy of copper, tin, and zinc. Chemically pure borax is considered a good flux for either silver soldering or brazing. A slightly carbonizing torch flame should be used.

229. WRENCHES:

End wrenches should not be used when the jaws are spread or when there are burrs on them, and it is also recommended that the end wrenches used in servicing work have ■ wide jaw or they will have a tendency to bite into the soft brass parts. Adjustable wrenches are necessary in the kit because of the odd sizes found in this work, but it is best to use an end wrench unless the adjustable wrench is fitted tightly to the nut. The reason for this recommendation is that adjustable wrenches are much more expensive and are sometimes used when not correctly adjusted for the nut, tending to abuse it. Box and socket wrenches, having "Tee" and ratchet handles, are necessary to complete a kit. Some popular sizes for wrenches are: ½ inch across flats for $\frac{5}{16}$ inch U.S.S. and S.A.E. cap screws. These cap screws are commonly used on compressors, expansion valves, float valve headers, etc. The $\frac{7}{16}$ inch across flat wrenches are needed for Frigidaire float valve headers, Absopure float headers, etc. The ¾ inch across flats are used for ¼ inch flare nuts which use $\frac{7}{16}$ inch-20 S.A.E. threads. The 1 inch across flat end wrenches fit the ½ inch flare nuts which use ¾ inch-16 S.A.E. threads. The box and socket wrenches are more

usable if they are double broached (12 point). A very useful wrench for flare nuts is the double broached wrenches now made for automobile water pump packing nuts. Figure 171.

230. SERVICE VALVE WRENCH:

The service valves are usually constructed with a square end milled on the valve shaft and need ■ special wrench to manip-

Fig. 171. Flare nut wrench (double broached)
(Courtesy of: J. H. Williams & Company)

ulate them. This tool usually has a ratchet and a fixed end for this kind of work. It may be mentioned here that, when cracking valves, the fixed end only should be used; when opening and closing valves through any appreciable distance the ratchet end may be used. Figure 172.

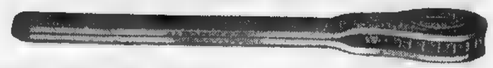


Fig. 172. A service valve ratchet wrench
(Courtesy of: The Imperial Brass Manufacturing Company)

231. SERVICE VALVE WRENCH ADAPTERS:

Many companies use valve stems other than the ¼ inch square; some valve stems are constructed in such a manner that the milled end is inside the valve body, necessitating a socket wrench to manipulate it. For these reasons adapters are available in the various sizes. The male, or drive, part of the socket is usually ¼ inch square although "Snap-on"

and a few others use a larger drive ($\frac{9}{32}$ inch). The socket or opening which fits the valve stem comes in three sizes: $\frac{3}{16}$ inch, $\frac{7}{32}$ inch, and $\frac{1}{4}$ inch. Most of these valve stems have internal packing gland nuts, and special sockets must be used for these. Some Frigidaire and Norge valves are examples of the above. It is best to obtain these special sockets with ball-bearing grippers to prevent losing them when working in difficult positions. Referring to Figure 173, R-1 to R-5 illustrate these special sockets.

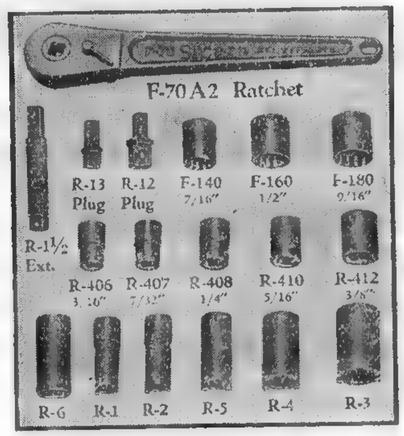


Fig. 173. Refrigeration service set
(Courtesy of: Snap-On, Inc.)

232. FITTING RESURFACERS OR REFACERS:

After a fitting has been used for a number of times and tightened and loosened repeatedly, the 45° flare surfaces become worn. To true up the surface again, a special tool may be used. This tool consists of a 45° end reamer built into a special jig with adapter threads for every size fitting. A "Tee" handle is used to manipulate the reamer. Badly worn fittings should always be replaced rather than repaired. Figure 174 illustrates a fitting reamer set.

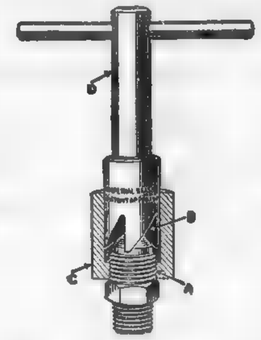


Fig. 174. A fitting reamer set
A. Flared end of fitting; B. 45-degree reamer blades; C. Adapter for each size of fitting; D. Reamer handle
(Courtesy of: Imperial Brass Mfg. Company)

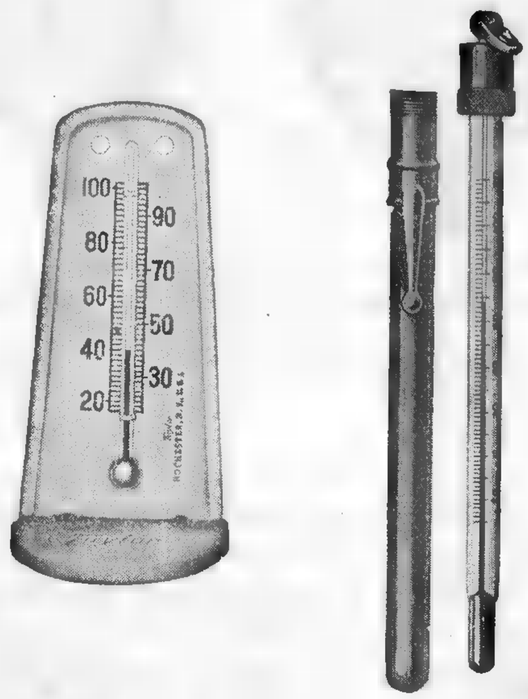


Fig. 175. Special refrigeration thermometers
(Courtesy of: Taylor Instrument Companies)

233. THERMOMETERS:

Two tools that the service man must be especially careful of are the thermometer and gauge set. The thermometer is used to check the cooling unit temperature, the refrigerator box temperature, and the condensing unit temperature. To determine whether the thermometer is accurate, an ice bath may be used, and the thermometer should check within 1° of 32°F. Usually the thermometer carried by refrigerator service men will not go up to 212°F.; therefore, the ice bath is the only check that can be used. Figure 175.

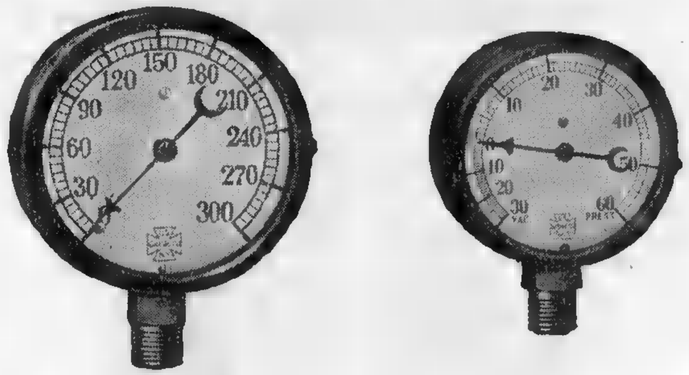


Fig. 176. Pressure gauges for servicing refrigerators
A. The high pressure gauge; B. The compound or low pressure gauge
(Courtesy of: United States Gauge Company)

234. GAUGES:

Inasmuch as the gauges that the service man uses are the instruments whereby he determines exactly what is happening inside the system, it is evident that these gauges must indicate correctly. This necessitates very accurate gauges and a periodic recalibrating of these gauges to reset them to their original accuracy. The two gauges used are the high pressure gauge, used on the high side of the system, and the compound gauge used on the low side of the system. These two gauges are calibrated quite differently. Figure 176.

Instruments have been designed to calibrate gauges accurately; any shop that uses a large number of gauges or is remotely situated should have one of these instruments on hand for calibration. These instruments are usually built on the basis of dead weights for calibration above atmospheric pressure, and a mercury column indicator for pressures beneath atmospheric, or vacuum. The high pressure gauges have a range as shown, of 0-300 pounds per square inch pressure, but this does not protect these gauges from being harmed at lower pressures. A rapidly fluctuating pressure at any pressure will soon harm the gauge. A sudden release of 300 pounds per square inch into the gauge will also injure it. The most popular gauges have a 2½-inch dial and use a ⅛-inch pipe, male thread. However, many have a ⅛-inch pipe female thread; a service man should use another fitting ⅛-inch pipe male by ⅛-inch female to protect it. The compound gauge especially should be protected from any abuses and sharp pressure fluctuations. These gauges should be calibrated at least once every month. By calibration is meant that they should be checked on a machine using a master gauge. They must be checked over their full range or scale.

The compound gauge (Figure 176B), may be obtained in various calibration ranges such as 30 inch Vac-0-60 pounds per square inch, 30 inch Vac-0-90 pounds per square inch, and 30 inch Vac-0-120 pounds per square inch. Compound gauges should never be used on the high pressure side of a system. When using a compound gauge on some rotary compressor machines, in which the high pressure may back up through the compressor while the compressor is stopped, a

30-inch Vac-0-120 pounds per square inch gauge should be used.

One company is now marketing a special compound gauge which, in addition to the usual pressure calibration, 30 inch Vac-0 pounds per square inch, has three additional scales which give the temperature corresponding to the various pressures for such refrigerants as sulphur dioxide, methyl chloride, and Freon. This extra scale makes it unnecessary to refer to pressure temperature curves for common refrigerants in order to check operating pressures.

235. CARE OF OIL:

In the mechanical refrigerator the moving parts, of course, must be lubricated with oil in order to have long life and efficient performance. This oil is of special grade, usually rather light, and is also specially treated to remove all moisture and corrosive compounds. When removing oil from a compressor, it must be placed in a sealed container so that moisture cannot get to it. If it is discolored throw it away. Never refill a refrigerator with discolored oil. Use new oil.

The oil (mineral oil) is obtainable in 1-gallon cans, 5-gallon cans, and in barrels. The price varies somewhat with the grades, such as a low pour-point oil is more expensive than one having a higher pour-point value. The pour-point of any oil is the temperature at which it starts to flow. For domestic machines with refrigerant temperatures as low as 0° F. to 5° F., a pour-point of –20° F. is desirable. Always seal an oil container after having drawn some oil from it.

236. CARE OF REFRIGERANT CYLINDERS:

The refrigerant cylinders should be stamped with an I.C.C. stamp (Interstate Commerce Commission) and should also

have a date on them. The cylinder should not be used when the date on the cylinder is more than 6 years old. Refrigerant manufacturers request that all cylinders be returned to them each 6 months or more often in order that the valve fittings and the complete cylinder may be carefully checked. This service assures safer cylinders. The service man's cylinders are called 5-pound cylinders; they are equipped with a service valve having a $\frac{1}{8}$ inch pipe female connection, Figure 177. This size of cylinder is not equipped with a safety fuse plug. The cylinder will hold 5 pounds of sulphur dioxide, 3 pounds of methyl chloride, and just a little more than 1 pound of iso-butane (Freezol).

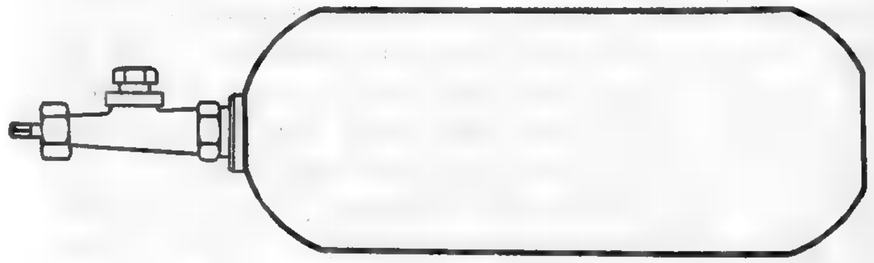


Fig. 177. A refrigerant storage cylinder

The cylinders for the various refrigerants obviously should not be interchanged; to help prevent this, different colors are painted on the cylinders. Silver and black represent sulphur dioxide cylinders, orange and black represent methyl chloride cylinders, and red and black represent iso-butane, while yellow and silver represent Freon. When purchasing refrigerants, 100 and 150 pound containers should be obtained. This permits a much lower price per pound of the refrigerant. The transferring of the gas from this large cylinder to the service cylinder should be carefully performed and a record kept of how much has been taken out. Add 3 per cent to account for gas losses. Service men

also use cylinders of the following sizes for large jobs and they are all equipped with safety fuse plugs; a 10-pound sulphur dioxide (a 6-pound methyl chloride), a 25-pound sulphur dioxide (a 15-pound methyl chloride), and a 50-pound sulphur dioxide (a 30-pound methyl chloride). A cylinder should be thoroughly rinsed out, periodically using carbon tetrachloride for the impurities getting into the refrigerants may be very corrosive to the refrigerating system.

One can tell whether or not there is refrigerant in a cylinder by shaking it and listening to the movement of the liquid, or by tapping the sides of the cylinder, which will indicate the level by changing its tone as the pounding passes the liquid level. The cylinder valves should receive the same care as the service valves of a refrigerator. The valve is a packed, one-way valve; the packing nut should always be kept tight unless using the valve, and the opening should always be sealed with a plug when not in use.

Never fill a refrigerant cylinder completely full of refrigerant because the cylinder might burst due to hydrostatic pressure. The safe limit is 85 per cent full.

Service tanks should be weighed before and after filling, for in this way the amount of refrigerant in the tank may be readily determined. In charging a refrigerator the service tank should be placed on accurate scales and only the specified weight of refrigerant charged into it.

237. BRINE:

Many domestic refrigerators have the cooling unit in a brine filled tank, particularly if the unit is of the direct expansion system. Brine tanks are also used on some flooded systems preferably those using a high side float valve.

The advantage claimed for these brine tanks is that the quantity of the brine acts as a storage for refrigeration; it will absorb considerable heat from the box between cycles of operation of the condensing unit thereby lengthening the interval between cycles of the unit. The term "hold over" is applied to cooling units that are designed to provide refrigeration between running periods of the condensing unit.

238. COMPOSITION OF BRINE:

The older refrigerators used a calcium chloride (CaCl) brine. This brine was composed of a solution of about 2½ pounds of CaCl in a gallon of water and usually would not freeze above 0°F. Care should be taken when mixing the brine because of the heat generated. Never mix the brine in the cooling unit itself. To help prevent corrosion, a little bichromate of soda is very useful.

Later models use alcohol or glycerine brine as they have less corrosive actions on the metals. Alcohol and glycerine brine may be used where CaCl has been used if it is desired.

The usual alcohol brine consists of 30-40 per cent alcohol (Formula No. 1) and water. This brine will not freeze above 0°F. Glycerine brine is made of 40-45 per cent glycerine in water solution. This will not freeze above 0°F. See Paragraph 446 for details.

239. THE SERVICE SHOP:

The specialized refrigeration service shop has appeared as a result of a definite need. A typical service shop is that maintained by large, factory-authorized, service organizations, which sell, maintain, service, and repair equipment. They usually comprise a completely equipped repair shop, employing one or two full-time men who repair equipment that is brought in by the service organizations. In most large cities a number of independent service men may be found who are

doing refrigeration service work as individuals. These one-man organizations rarely have the equipment or time to overhaul compressors or other parts. Many larger refrigeration service organizations also prefer not to set up an

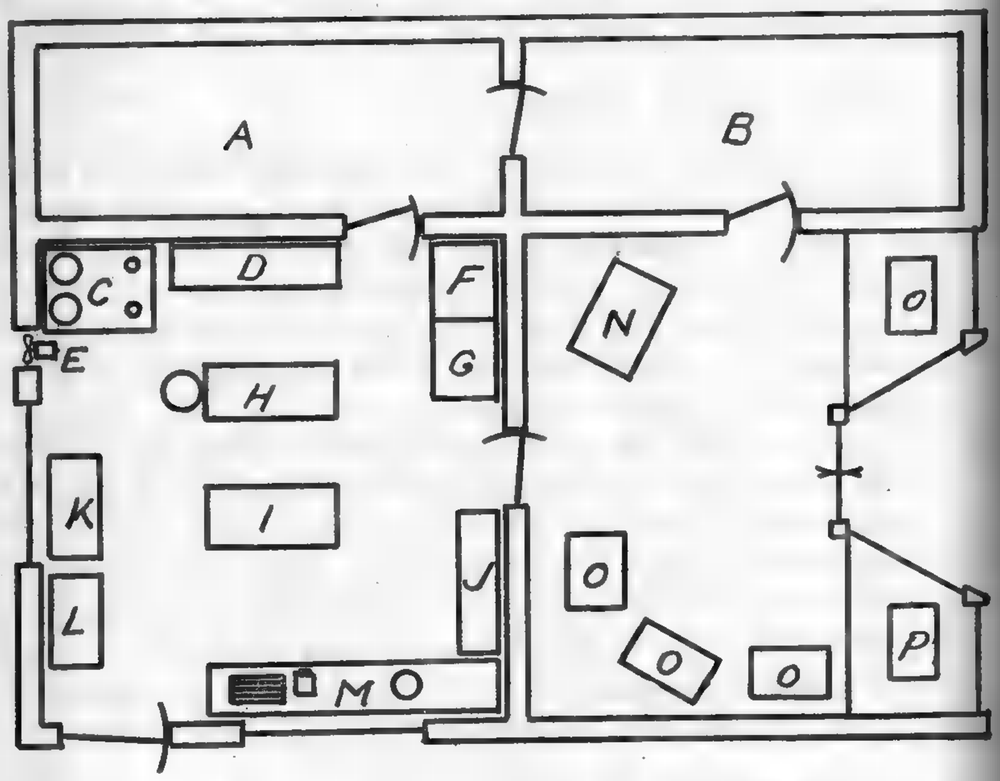


Fig. 178. A typical refrigerator sales and service shop
A. Stock room; B. Refrigerator storage room; C. Charging outfit; D. Drying oven; E. Exhaust fan; F. Small parts rack; G. Tool cabinet; H. Tear-down bench and cleansing bath; I. Assembly bench; J. Repair bench; K. Old parts; L. Rebuilt parts; M. Testing bench; N. Office desk; O. Refrigerators; P. Refrigerator unit

elaborate shop equipment which they are not able to keep operating continuously. Catering to these service organizations, service repair shops may be found which rebuild and repair equipment. They are usually operated by men who

are skillful mechanics and who have good equipment. These shops repair the equipment for the independent service men. Such a shop may be termed a wholesale repair establishment. Figure 178.

The following paragraphs are meant to offer suggestions concerning the organization and equipment of such a repair shop.

The purpose of the refrigeration service shop is to repair all equipment brought in by the service men and to keep on hand the necessary parts, equipment, and supplies for installing and servicing.

The shop should be centrally located in respect to the distribution of refrigerating equipment in the locality. It should also be provided with shipping facilities and parking space. The shop should have some display space, or window space, to provide an exhibit of supplies, parts, equipment, and services available.

240. SHOP EQUIPMENT:

The type of work to be done determines, to a great extent, the equipment necessary for such a shop. One may choose from the following list of equipment the items necessary to do the work desired. The list is complete enough to enable one to perform any manner of service or repair work.

Lathe
Grinder and buffer
Air compressor
Welding equipment
Lapping blocks
Charging apparatus
Compressor testing stand
Motor testing stand
Drying oven

Float control tester
Expansion valve tester
Cold bath for thermostatic controls
Purging equipment
Oil dispenser
Storage racks for A. Completed work
B. Rebuilt work
C. Unfinished work
Refrigerant distilling apparatus
Cleaning bath
Acid dip bath
Paint spraying booth and equipment
Assembly bench
Tear down bench
Supplies
Shop tools

241. LATHE:

A lathe may be used for resurfacing valve plates, for lapping crankshaft seal shoulders, for straightening crankshafts, for turning motor armature commutators, for refacing motor bearings, for straightening armature shafts, for winding tubing, for opening water-cooled liquid receivers, and for doing many other things. The lathe should be a screw-cutting type with at least a 24-inch bed and a 9-inch swing. Figure 179. It should be provided with a grinding attachment to make grinding crankshaft shoulders possible. It should also be equipped with a steady rest for keeping liquid receivers true when cutting them open.

242. GRINDER AND BUFFER:

An electric grinder and buffer combination may be used for conditioning shop tools and for cleaning and polishing the various brass parts of a refrigerating mechanism. All rebuilt units have a much neater appearance if the brass work is given a polish. A machine equipped with its own stand is to be preferred; also a ball-bearing motor, having a built-in switch is desirable.

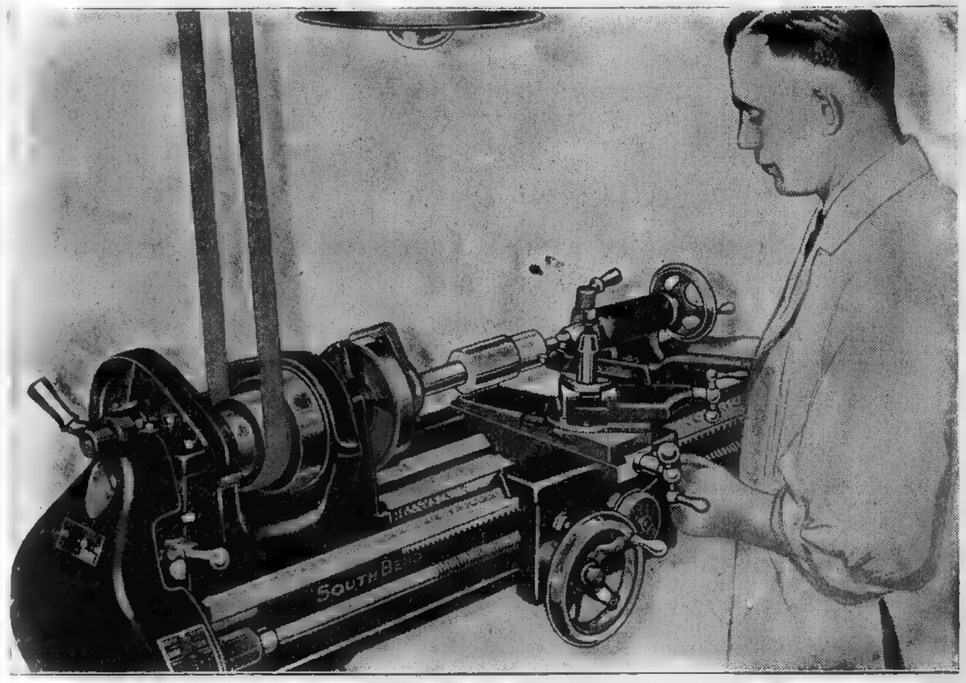


Fig. 179. A refrigeration shop lathe
(Courtesy of: The South Bend Lathe Works)

243. AIR COMPRESSOR:

An air compressor is valuable in the shop for many purposes; air pressure is needed to test different parts of the refrigerating system upon assembly, and to furnish compressed air for the city gas and air torches. Air is also needed for blowing out screens and other parts of the refrigerating system

when cleaning them. A dehydrator should be mounted in the suction line of the compressor to assure that the air which is delivered by the compressor is dry. An old refrigerator condensing unit may be used as an air compressor by using a large receiver. A pressure of 125 pounds per square inch to 150 pounds per square inch should be maintained. The intake side of the compressor may be used to evacuate parts when dehydrating, or when a vacuum is needed for testing a mechanism. This compressor may be used to supply air for spray painting if its capacity is adequate.

244. WELDING EQUIPMENT:

The welding equipment needed consists of an oxygen tank, an acetylene tank, regulators and gauges, hose, and a torch. This equipment will be valuable for soldering, brazing, and welding the various parts of refrigeration systems. It may be used in cases of breakage, or to reassemble liquid receivers after new water-cooling coils have been installed. All welding tanks should be provided with suitable supports in order to eliminate any danger of their being knocked down. The local code on welding should be thoroughly understood if welding equipment is set up and operated. Never operate the welding outfit near the paint booth. CAUTION: Never use oxygen, acetylene, or any other welding fuels, for the purpose of developing a pressure in refrigeration tubing, piping, or equipment. Dry air or carbon dioxide are the only safe substances to use for developing pressures in refrigeration lines. A severe explosion is sure to result if welding gases are used.

245. LAPPING BLOCKS:

Lapping blocks are used to resurface accurately sylphon seal rings, valve plates, switch contact points, and valve disks. These blocks may be constructed of plate glass. Sandpaper blocks may be accurate enough for switch contact points.

Plate glass lapping surfaces, using oil and a very fine grinding compound, should be used for sylphon seal rings. Figure 153. It is difficult for a beginner to lap a surface accurately. One should use very little lapping compound, but considerable oil; the work should be moved in a figure eight motion over the block surface. The article that is being lapped should be held between the thumb and the index finger only; as the lapping process advances, the article should be turned

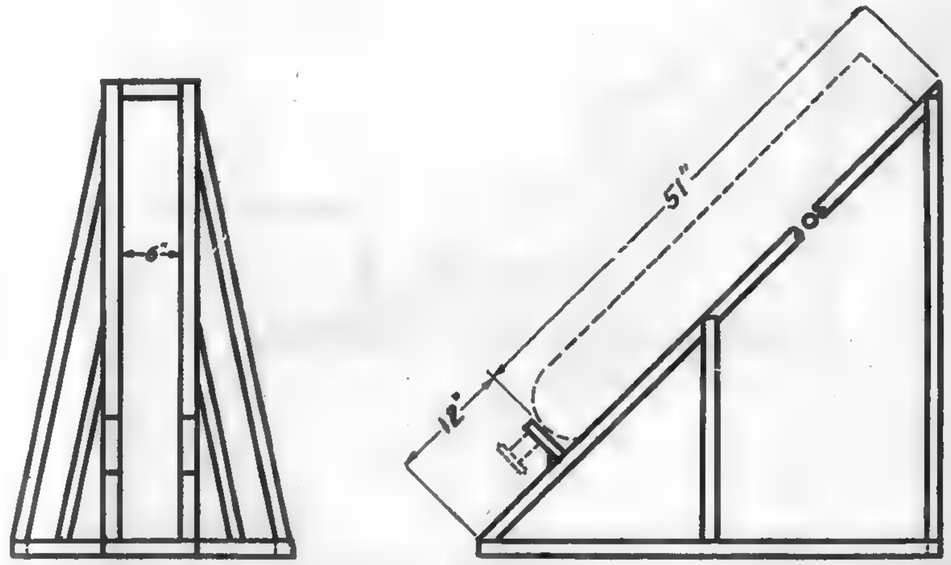


Fig. 180. A metal stand used for holding large refrigerant cylinders to facilitate transferring the refrigerants

in the fingers to compensate for any uneven pressure that may be applied. One should use the entire lapping surface of the block evenly; otherwise low spots will be worn into the block and accurate work cannot be produced. A lapping block may be kept accurate by occasionally lapping it on another lapping surface, for this will tend to wear away the high spots on both the blocks. However, for most accurate lapping, three blocks should be used and these blocks periodically lapped against each other.

246. CHARGING APPARATUS:

Two types of charging apparatus may be used. The simplest type consists of a stand on which a 150-pound refrigerant drum, or cylinder, may be mounted in an inverted position. This stand must be so constructed that the cylinder valve is easily accessible. Figure 180. A ¼″ charging line should run from the storage cylinder to the service cylinder as shown in

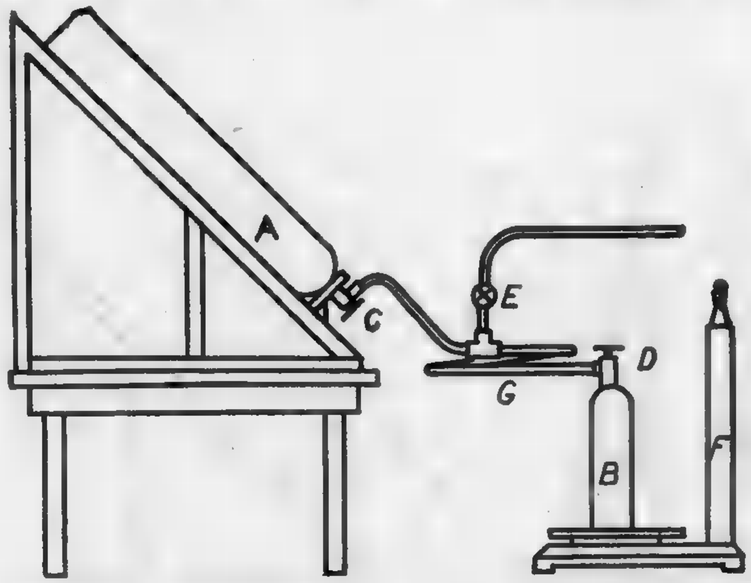


Fig. 181. Set up for transferring refrigerants from a storage cylinder to a service cylinder and weighing

A. Storage cylinder; B. Service cylinder; C. Storage cylinder valve; D. Service cylinder valve; E. Purging or evacuating valve; F. Weighing scale; G. Horizontal tubing loop

Figure 181. This charging line may or may not have a purging line tapped into it. It should be approximately horizontal and at least 4 feet long. By carefully heating the storage cylinder slightly, or preferably by cooling the service cylinder, the refrigerant may be easily transferred. The exact amount of refrigerant transferred may be determined by placing the service cylinder on a weighing scale during the

charging operation. The charging line must be thoroughly purged before allowing the refrigerant to pass through it into the service cylinder. The purpose of the auxiliary line, which is connected to the main charging line through a valve, is to permit the purging of the small cylinder into some receptacle or outdoors. This thorough purging decreases the pressure in the service cylinder in addition to removing the air from

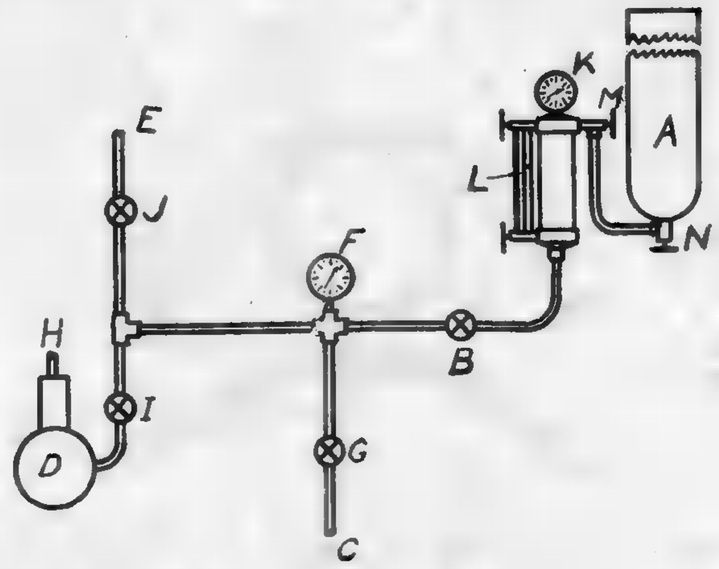


Fig. 182. Method of transferring refrigerant from a storage cylinder to a service cylinder by means of a charging board

A. Storage cylinder; B. Charging control valve; C. Connection to unit or cylinder to be charged; D. Evacuating pump; E. Purging line; F. Compound gauge; G. Disconnecting valve; H. Pump discharge; I. Pump control valve; J. Purge control valve; K. High pressure gauge; L. Liquid level sight gauge; M. Charging cylinder control valve; N. Storage cylinder valve

the line, which allows charging the service cylinder without heating or cooling either cylinder.

The other charging method is more complicated, but is very convenient when large quantities of refrigerant are to be handled. It eliminates the necessity of weighing the cylinders when charging. The device is called a charging board.

It uses an intermediate drum, having a reinforced glass liquid-level indicator built into it. Figure 182. The intermediate drum is permanently connected to the 150-pound storage cylinder by means of a copper line and a shut-off valve; it is then filled with the refrigerant. The level of the refrigerant is indicated in the glass sight level gauge which is calibrated in pounds of refrigerant. When a small cylinder is to be charged, the cylinder is attached to the intermediate drum and the connecting line is purged. After the cylinder is cooled, the opening of the necessary valves will allow the

Fig. 183. Two types of flexible charging lines
1. Interlocking brass core; 2. Durable compound covering; 3. Braided fabric outer covering; 4. ¼-inch S.A.E. brass connection compressed onto the tube
(Courtesy of: Imperial Brass Mfg. Company)

refrigerant to flow from the intermediate drum to the service cylinder. The amount being charged into the cylinder is indicated by the weight scale mounted on the liquid level gauge. Flexible metal and rubber charging lines are available and are very convenient to use. Figure 183.

247. COMPRESSOR TESTING STAND:

Compressors should always be carefully tested after being overhauled and before being put into service. Compressors

must be run-in for a number of hours after new bearings have been installed. In order to facilitate testing and running-in compressors, a compressor test stand should be used. This consists of a steel bench with some flexible means of clamping different sized compressors to it. Some test stand tops have grooves which make a very flexible clamping arrangement possible, or the top may be drilled and tapped

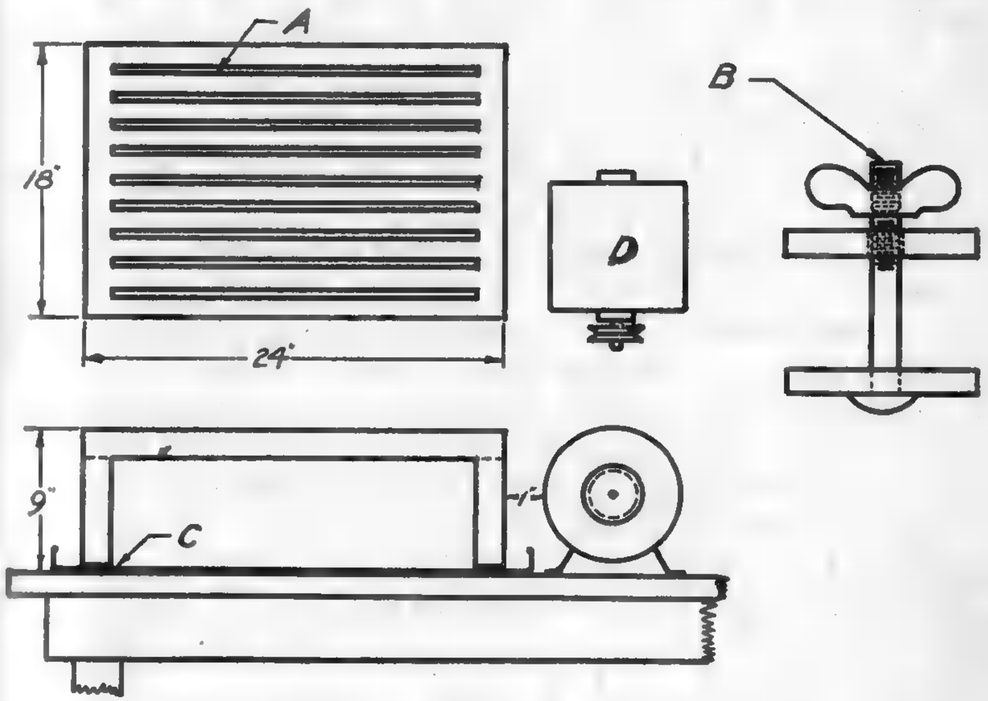


Fig. 184. A compressor testing stand made of ¼-inch x 1½-inch ∎ 1½-inch welded angle irons
A. ⅜-inch slots; B. 5/16-inch bolt; C. Oil catch pan; D. Electric motor

with a large number of holes in a definite pattern to enable clamping arrangements to be attached. The motor used for driving compressors on test should be ½ H.P. or more. Compressors on test must be driven at a speed corresponding to the normal operating speed. This necessitates an arrangement of pulleys whereby various compressor speeds may be

obtained. A variety of belt lengths will be found necessary to test various types of compressors. Figure 184. If possible all compressors, after being overhauled, should be run in on this stand from 8 to 24 hours before going into service. They should also be tested thoroughly to determine their operating characteristics. The best test is to determine the quantity of gas the compressor will pump under normally operating low and high side pressure. This is rather difficult to determine because of the elaborate set up of flow meters, regulating valves, and other instruments required. The exact method of doing this varies with various manufacturers. No uniform procedure can be specified here. Most methods depend upon the time required to develop a specified air pressure in a tank of a specified size. A fair estimate of a compressor's efficiency may be easily obtained by determining how high a vacuum the compressor can produce when operating against its normal head pressure. The time required for the compressor to draw a high vacuum is also an indication of its pumping ability. If the valves and pistons are in good condition, a compressor should maintain this vacuum after it has stopped. The compressor crankshaft seal may be checked by sealing the low side of the compressor and running the compressor with an 18-inch length of ¼-inch copper tubing connected to the discharge service valve. The free end of this tubing should be inserted in a bottle, half full of refrigerant oil. While the compressor is pumping the vacuum, bubbles will come out of this tubing. If the bubbles continue to come out of the tubing, they indicate a seal or low side leak. After the highest possible vacuum has been reached, no more bubbles should come out of the tubing. To establish the source of the leak definitely, put oil around the seal as the compressor runs; if the seal is leaking, the oil being sucked into the seal will momentarily stop the leak, and the compressor will cease to pump bubbles. This definitely locates the leak at the seal. A

good compressor should be able to produce 22 to 24 inches of vacuum against its normally operating head pressure and maintain it. A compressor testing stand may also be used to charge a compressor with oil. It is to be recommended that the quantity of oil added should conform to the compressor and to the amount of oil recommended by the manufacturer of that unit. Many times this information is not available, especially if working on obsolete models. A generally satisfactory method of charging a compressor with oil that will result in the correct quantity of fresh refrigerant oil of the proper grade is as follows: run the compressor, allowing the oil to be drawn into it, when the compressor starts throwing oil vapor out of its discharge opening, it is an indication that enough oil has been added.

248. MOTOR TESTING STAND:

Electric motors, when in need of repair, are usually taken to a wholesale electric motor repair shop to be overhauled. However, many of the refrigeration service companies prefer to repair as many of these motors as possible. In case rewinding the motor is necessary, this should be done in a shop equipped for this kind of work. In many cases when motors come in, it is a question whether the motor should be repaired or rewound. It is then necessary to test the motor carefully to determine its operating characteristics. To do this, a torque testing stand should be used. Figure 185. This consists of a stand and a group of pulleys with equal diameters to fit various sized motor shafts. The surface of these pulleys is smooth and flat. A torque arm lined with automobile brake lining is arranged to fit the pulleys. The length of the torque arm should be exactly 1 foot between its point of support on the scales and the center of the motor pulley. A spring loaded adjustment mechanism should be arranged on the

friction surfaces of the torque arm to enable various frictions to be produced between the torque arm and the motor pulley. The extremity of the torque arm is placed either on a spring scale or preferably on a platform scale. Figure 186. The torque of the motor can then be very accurately checked for stall condition and full speed load. The

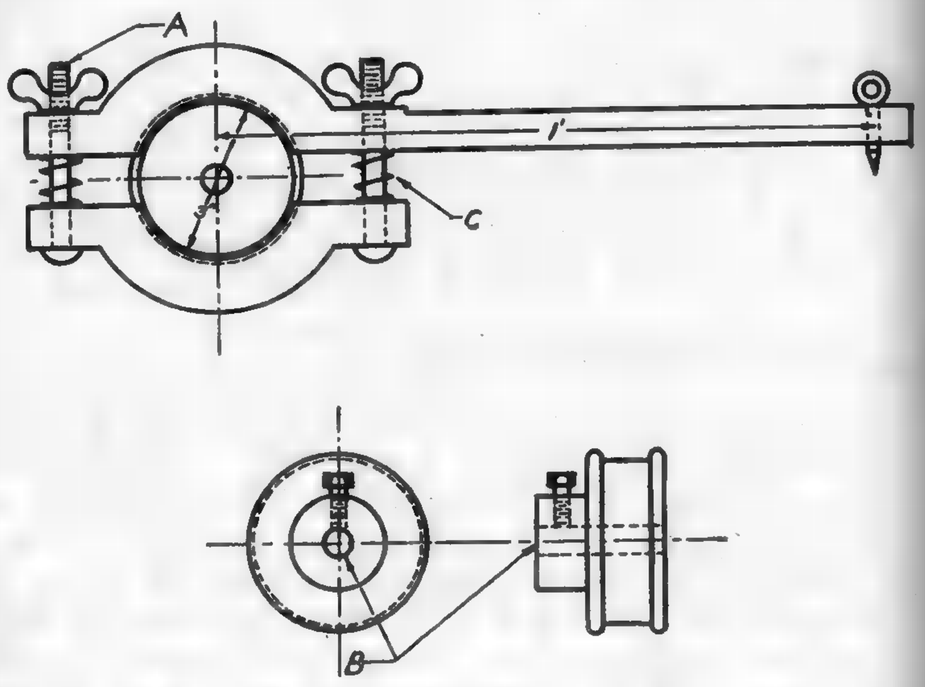


Fig. 185. Motor testing torque arm and pulley
A. 5/16-inch wing nut and bolt; B. Reamed holes for various sized shafts; C. Spring

torque obtained in this way may then be read directly from the scales in pounds feet. This data, if compared with the manufacturers torque ratings, will indicate the condition of the motor. The switch mechanisms and brush mechanisms of these motors may be checked by using this stand. It is recommended that ammeters, volt meters, and watt meters be used

to determine the current draw of the motor. The temperature rise of the bearings should be very carefully noted when testing the motors. A thermometer placed in the bearing oil reservoir is recommended for this purpose. The temperature rise should not exceed 72°F. above the room temperature.

249. DRYING OVEN:

All refrigerating apparatus must be thoroughly dry before

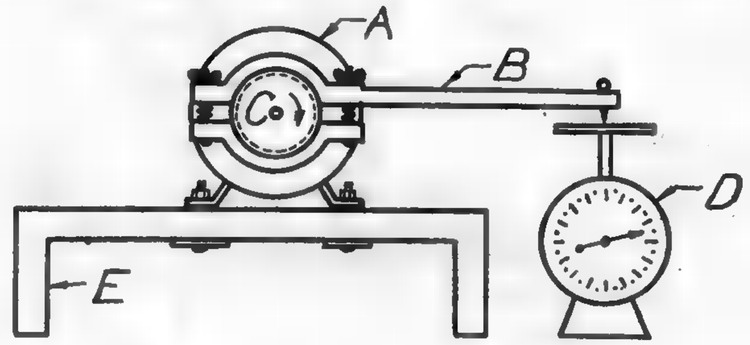


Fig. 186. Showing the use of a complete motor testing torque arm and pulley
A. Motor; B. Torque arm; C. Pulley; D. Weighing scale; E. Stand

being used. Parts become moisture laden while being repaired and should be thoroughly dehydrated after assembly and checking for working ability. This dehydrating may be done in two ways. One way is to place the part to be dried in the drying oven, which is an insulated cabinet using gas burners or electric heating elements, and heating it. Figure 187. The part should be maintained at a temperature between 200°F. and 250°F. for 24 hours in order to dry it thoroughly. A better method is to draw a vacuum during this heating period upon the parts to be dehydrated. It has been found that heating periods of 8 hours are long enough if a

high vacuum is maintained. Compressors should not be dehydrated with the oil charge in the compressor. Another method of dehydrating parts consists of producing a vacuum on the part to be dehydrated and then heating the part with a blow torch for a period of about 15 minutes at 1 hour intervals for at least 4 hours. Do not let the unit become warm enough to be uncomfortable to the hand, particularly parts that are soft soldered.

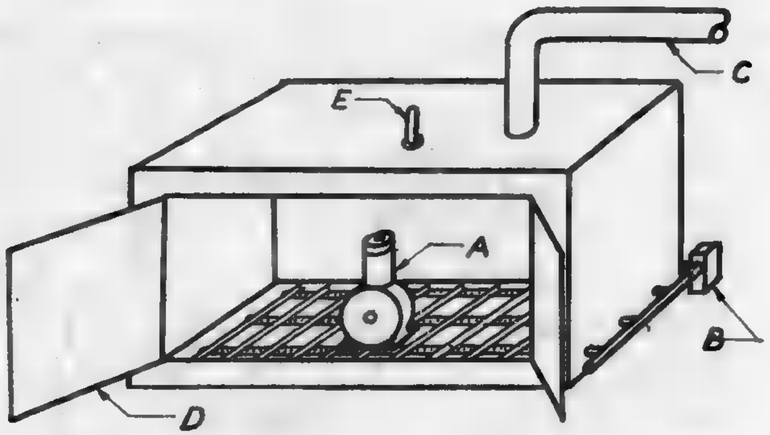


Fig. 187. A gas heated drying oven with an automatic temperature control
A. Compressor; B. Automatic gas control; C. Chimney for exhaust fumes; D. Door; E. Thermometer

250. FLOAT CONTROL TESTER:

After a float mechanism has been repaired in seat, needle, and float, it must be calibrated and tested before being installed in a coil. The method of calibrating a float consists in adjusting it until the needle closes with the ball on the center line. To test a float valve for leakage, one of two methods may be used. The liquid line connection to the float valve may be attached to a high pressure, dry air line and the float mounted in such a position that the float presses the needle lightly against its seat. Oil placed around the valve will

show the bubbles coming through if the needle is leaking. Sometimes a small leak may be remedied by holding the float valve in such a position that the needle presses against the seat, and then tap lightly upon the needle. Some companies prefer to check float valves by mounting the float on a special stand; with the aid of a pulley and weight system, impose a lifting force on the ball, equivalent to the lifting force imposed upon it when it is immersed in the refrigerant. The needle and seat are then tested for leaks using the dry air line. Other companies use an apparatus whereby the float valve

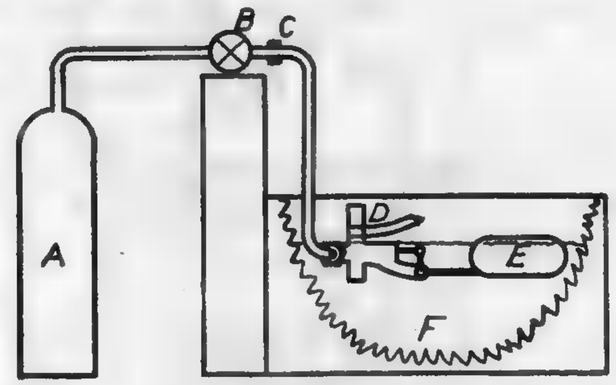


Fig. 188. A low side float valve testing stand
A. Dry air tank; B. Valve; C. Swing joint; D. Float header; E. Float ball; F. Carbon tetrachloride bath

mechanism is lowered into a quantity of liquid carbon tetrachloride after it has been connected to a dry air line. The appearance of bubbles will indicate a leak at the needle. Figure 188.

251. EXPANSION VALVE TESTER:

After an expansion valve has been overhauled, the screen cleaned, the needle and seat repaired, the bellows cleaned, and the anti-freezing solution put in the bellows housing, the expansion valve should be thoroughly tested before being put

into service. This test consists of checking the needle, seat, and bellows for leaks under their full pressure range. To test an expansion valve, needle, and seat, one must connect the liquid line fitting to a high pressure dry air line, and the cooling coil connection to a small metal drum. A 6 cubic inch tank is of sufficient size. A very delicate manometer, or pressure gauge, is connected to this small tank and registers

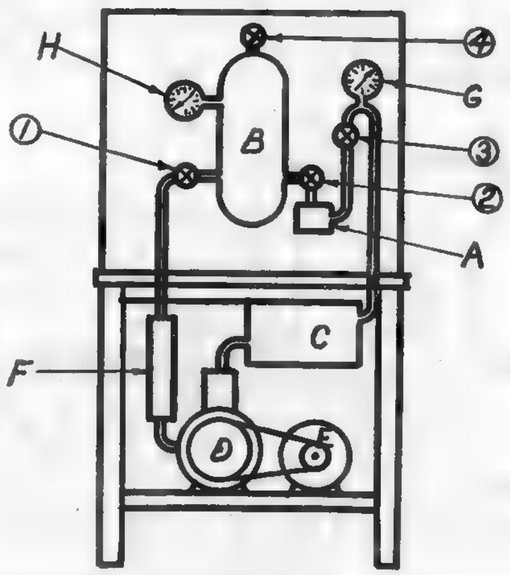


Fig. 189. An expansion valve testing apparatus
1. Suction line valve; 2. Tank valve; 3. Pressure valve; 4. Pressure release valve; A. Expansion valve; B. Air tank; C. Air storage tank; D. Air compressor; E. Motor; F. Dehydrator; G. High pressure gauge; H. Low pressure gauge

positive pressure and partial vacuums. This drum must also be connected to an air pump in order that a vacuum may be produced on the tank after the expansion valve has been connected to it. Figure 189. Turn the expansion valve adjusting screw all the way out and then produce a vacuum on the tank. Allow the expansion valve to remain in this condition for 5 minutes; if the low side pressure rises, the needle

or the bellows is leaking. Now turn the expansion valve adjustment in slowly and note the pressure rise with each turn of the adjusting screw. After the screw has been turned in a certain number of turns, a positive pressure will be registered in the tank. This pressure will increase with each turn of the screw to a certain point when the pressure will increase uncontrolled. This point is the critical setting of the valve, and it should be well outside the normally operating pressure ranges of the expansion valve. To test the needle for leaks after the expansion valve has been adjusted to a 5-pound reading, one should wait for 5 or 10 minutes; if the drum pressure does not vary from the 5-pound setting, the expansion valve needle is holding O.K. With a 10-pound pressure registered on the tank gauge, test the bellows for leaks by putting refrigerant oil around the adjusting screw opening. Bubbles appearing here will indicate a leaky bellows.

252. COLD BATH FOR THERMOSTATIC CONTROLS:

Thermostatic motor controls and thermostatic expansion valves must be adjusted by means of a controlled temperature bath in order to test these controls for operating range and condition. A thermostatic expansion valve should be tested like the expansion valve (Paragraph 251), but with the thermostatic bulb placed in an ice water bath or in a refrigerant bath maintained between 30°F. and 32°F. After the expansion valve has adjusted itself to this temperature, it may be tested, using the same process as in Paragraph 251. Thermostatic motor controls operate at ranges varying from —10°F. for ice cream cabinets up to temperatures of 45°F. for grocery cabinets, etc. To produce temperatures for testing purposes over these ranges, the best device consists of a small refrigerating apparatus, which uses an automatic ex-

pansion valve connected to a small coil that has been immersed in a brine solution. A thermometer well should be built into the brine solution. Figure 190. The control bulb of the motor control which is being tested is then immersed in this solution; after a period of ½ hour, during which time the bulb temperature has become stabilized, the mechanism may be adjusted to the correct cutting-out temperature, and the control adjusted to snap open the switch at this point.

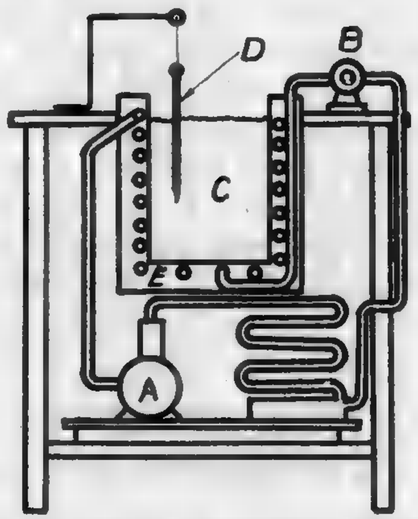


Fig. 190. A cold bath for testing thermostatic expansion valves and motor controls
A. Refrigerating unit; B. Expansion valve; C. Brine bath; D. Thermometer; E. Insulated cooling coil

The correct cutting-in point may be obtained by warming the brine, by shutting off the refrigerating unit, by adding some hot water, or by using a torch. One must be very careful to do this slowly in order to produce even temperatures.

253. PURGING EQUIPMENT:

Often low side float coils, complete condensing units, or complete refrigerators are brought into the shop, and it is necessary to empty them of their refrigerant before working on them. This refrigerant may be saved if provisions are available for storing and redistilling it; otherwise it is best to discard the refrigerant because of the impurities in it. Refrigerants may be irritating and charged with oil; therefore they cannot be discharged directly outdoors. In all cases the oil in the refrigerant should be carefully handled to prevent damage to neighboring property. Sulphur dioxide and ammonia may be discarded by discharging them down a tile or brick sewer drain. Iron pipes should not be used to carry sulphur dioxide refrigerants, while copper tubing should not be used to carry ammonia. In discarding refrigerants two precautions must be observed. The purging line should be provided with a check valve to prevent the backing up of the refrigerant into the room; a strong flow of water should be run down the sewer while the purging is going on in order to dissolve the refrigerant. Many companies cause their purging lines to run out-of-doors and discard both their oil and their refrigerant out through this line, but trouble has resulted from this system and, if possible, it should not be used. A good system of discarding the refrigerant is to run it through a chemical which will neutralize it.

The purging stand should be hooded, and an out-of-doors exhaust fan should be run from this hood to take away any accidental leaking of refrigerant from the work shop. This fan should be large enough to take care of the ventilation for the complete shop to insure that under practically all circumstances the work in the shop will not be interrupted. The location of the fan should be low, for most refrigerants and their gases formed under room temperature are heavier than air. Some means of taking care of the oil in the refrigerant should be provided as part of the purging stand. This may best be done by means of ■ tank into the top of which the purging line enters. The purging outlet line then

continues from another part of the top of the tank to the outdoors or into the sewer. Between the two openings of the tank, a baffle should be constructed to cause the oil to settle out of the refrigerant gas as it passes through the tank. The bottom of the tank should be provided with a hand valve to enable one to drain the oil periodically. A check valve should be located in the line between the tank and the mechanism which is being purged to prevent the backing up of fumes into the room after the purging is completed. Figure 191.

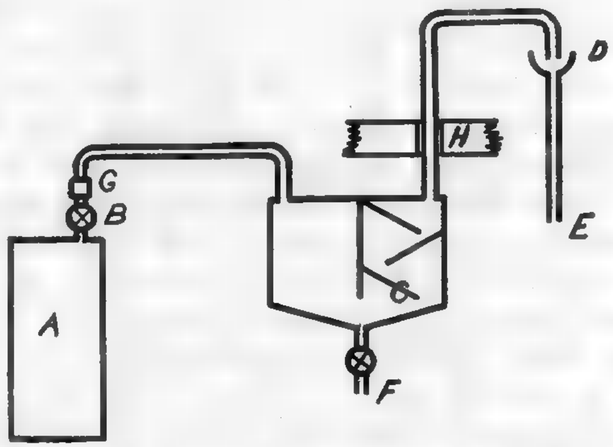


Fig. 191. A diagram of a purging line and oil trap
A. Old refrigerant; B. Valve; C. Oil trap; D. Vent; E. Tile drain; F. Oil drain; G. Check valve; H. Building wall

254. OIL DISPENSER:

It is more economical to buy refrigerating oil in large quantities, such as in barrel lots. Some means must be provided for dispensing this oil into smaller containers or into refrigerator machines in a manner that will keep it clean and dry. This is best done by building a wooden cradle for the barrel to enable mounting it on its side; a faucet may then be screwed into the bung of the barrel. No air openings into the

barrel should be provided, but if the oil does not flow out, the sealed opening may be cracked, allowing a little air to flow into the barrel. If an air opening is permanently provided, the oil will absorb too much moisture and may cause trouble in refrigerators in which it is used. A record should be kept

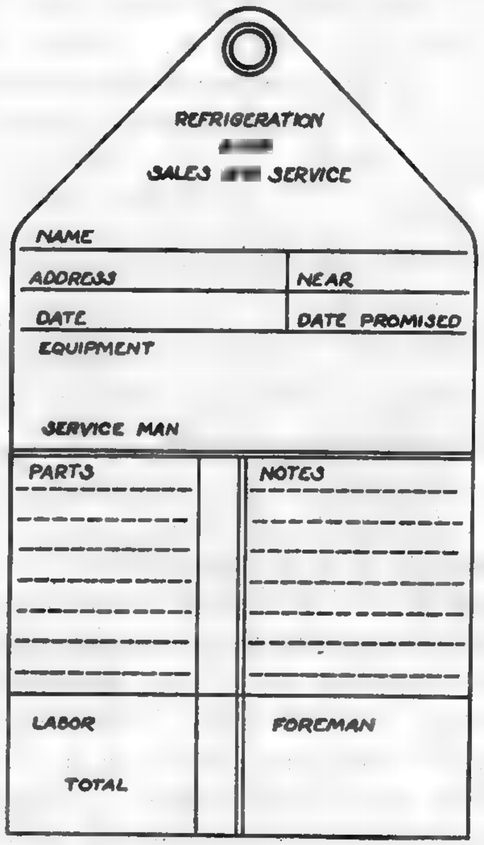


Fig. 192. A typical refrigerator shop repair card for refrigerator parts

of the amount of oil drawn from the barrel in order to know the amount of oil in the barrel at all times.

255. STORAGE RACKS:

Separate stands should be provided for completed work, re-

built work, and unfinished work. These stands may be constructed of either wood or metal. All work that is taken in should be tagged immediately to indicate the owner, the date brought in, and the repairs needed. This card should also contain space for marking the date the work was completed and the time when the unit was put into service. This tag may then be filed for reference. Sometimes the drawers or shelves of these racks are provided with holders for cards rather than tags. The card system permits a much neater record. Figure 192.

256. REFRIGERANT DISTILLING APPARATUS:

As previously mentioned, used refrigerants should be discarded because of the oil impurities dissolved in them. However, if the amount of business warrants it, a distilling apparatus may be used to cleanse, purify, and remove the oil from the refrigerant. A distilling apparatus consists of five main parts: (1) moisture removers in the form of large calcium chloride, or zinc moss containers, (2) an acid neutralizer consisting of activated alumnia or zinc moss, (3) a vaporizer, (4) a condensing mechanism, and (5) an oil trap. In detail the complete apparatus consists of a refrigerating machine having an extremely large liquid receiver. This machine may have either a water- or an air-cooled condenser; a water-cooled one is preferable. A large oil trap is connected between the compressor and the condenser. This automatically collects the oil and removes it from the refrigerant. The dehydrator and neutralizer equipment should be installed in the suction line which is then attached to the drum of the refrigerant to be distilled. Figure 193. As the compressor runs, it vaporizes the old refrigerant in the storage drum; when its vapor passes through the drying and neutralizing chemicals, its moisture and acidity is removed. The gas is

then compressed and passed through an oil trap which removes practically all the oil vapor from it. From here it passes into the condenser, and upon condensing collects in the liquid receiver, cleansed of its impurities. Some distilling apparatus uses double and triple oil traps and the same number of neutralizers and dehydrators. The neutralizers and

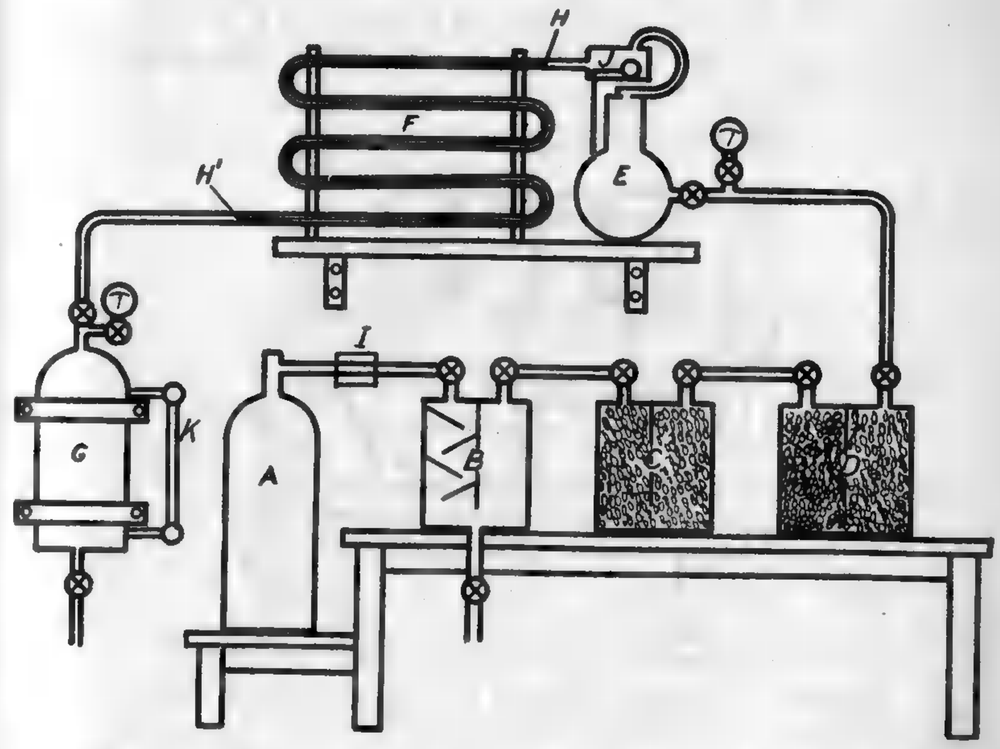


Fig. 193. A cleaning and distilling apparatus for refrigerants
A. Old refrigerant; B. Oil trap; C. Neutralizer; D. Dehydrator; E. Compressor; F. Condenser; G. Storage cylinder; H-H. water cooling coil; I. Expansion valve; J. Automatic oil trap; K. Liquid level indicator

dehydrators used must be replaced often in order to keep the chemicals active. A distilling system similar to the above is sometimes constructed, using steam or heating coils for the vaporizing means and very cold water for the condensing means.

257. CLEANSING BATHS:

When a refrigerating mechanism is brought into a shop, it should be thoroughly cleaned. The most popular cleanser is carbon tetrachloride which is a non-inflammable fluid and is also a moisture absorbent. The cleaning tank should consist of a large galvanized tank having a fine mesh screen located approximately an inch above the bottom. The tank should be partially filled with cleansing liquid. Paint brushes help

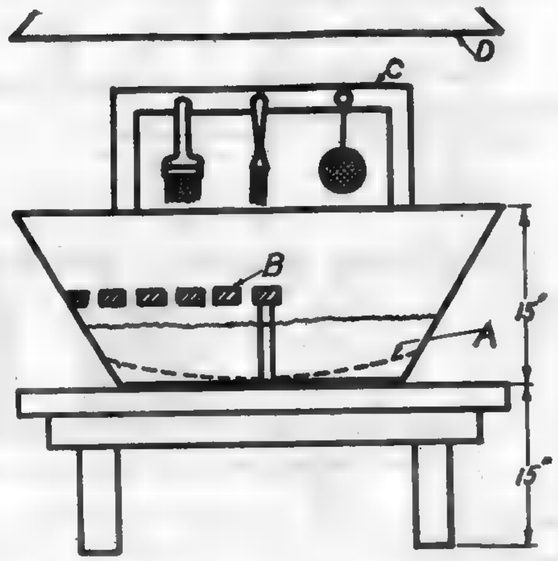


Fig. 194. A cleaning bath and rack for refrigerator parts
A. Screen; B. Wood slats; C. Brush holder; D. Venting hood

clean the parts; a wire brush may also be used. Figure 194. A high pressure air jet may be used to clean otherwise inaccessible parts.

After being cleaned, the parts should be rinsed and then placed upon a drying rack located above the bath. Because of fire hazard, gasoline should not be used in cleaning tanks. Carbon tetrachloride cleaning tanks should be vented outdoors, or the fumes will become quite bothersome. A clean

supply of cleansing liquid should be used every day, or more often, depending upon the amount of work done. An economical arrangement consists of the use of two tanks. The first tank, containing the dirtier fluid, is used for the first cleaning; and the other tank, which contains clean fluid, is used for the final cleaning and rinsing.

258. ACID DIP BATH:

Many brass parts of the refrigerating system such as fittings, nuts, service valves, etc., become discolored and greasy after

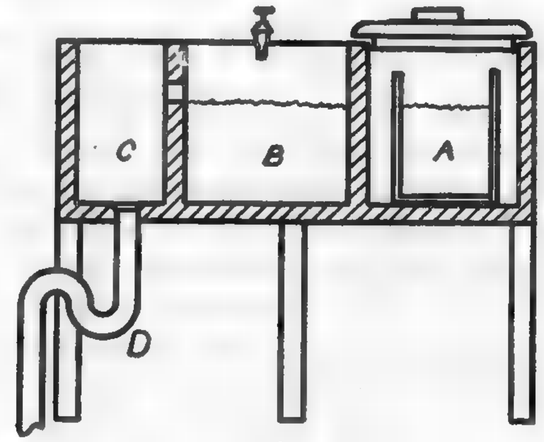


Fig. 195. An acid dip bath for chemically burnishing brass refrigerator parts
A. Acid; B. Water and soda; C. Drain basin; D. Trap

period of use. When such a mechanism is brought into the shop, it is usually desirable to clean it and to make it look like new. A buffing wheel may be used for this purpose, but many crevices and corners are inaccessible to the wheel. A quantity of sulphuric acid in an earthenware crock, which is covered with a wood plate and heated to a temperature of 100°F., is a very good cleaner for brass parts. Attach the parts to be cleaned to an iron wire or put them in a perforated earthenware dish; then immerse in the hot acid for two or three minutes. The operator should wear rubber

gloves, apron, and goggles, when using the acid cleaning bath. Brass fittings, cleaned as above, must be immediately rinsed in an earthenware crock full of clean water to wash away the acid. Figure 195. The fittings will now have a very clean appearance. Nitric acid may also be used and it does not have to be heated. However, it is a much stronger acid and therefore more dangerous. Keep acid cleaning crocks under a well ventilated hood to minimize inhaling of the fumes. These fumes are also very deteriorating and corrosive to practically all metals.

259. PAINT SPRAYING BOOTH AND EQUIPMENT:

Duco and lacquer paints are often used for finishing refrigerator cabinets and parts. A paint spraying outfit used in a ventilated booth is the best means for repainting these cabinets. The old paint should be removed with paint remover, a scraper and sandpaper. A priming surface should then be applied followed with at least two coats of the finish paint. The painting equipment may also be used for repainting compressors, bases, motors, receivers, etc.

260. SUPPLIES:

The refrigeration repair shop should have on hand a sufficient quantity of supplies to perform adequately the work encountered. Supplies consisting of the following should be kept on hand:

- Refrigerant
  - Sulphur dioxide
  - Methyl chloride
  - Freon
  - Iso-butane
- Refrigerant oil

- Tubing
  - 1/4-inch O.D.
  - 5/16-inch O.D.
  - 3/8-inch O.D.
  - 7/16-inch O.D.
  - 1/2-inch O.D.
  - 5/8-inch O.D.
- Fittings
  - Flared
  - Pipe
  - Soldered
- Valves
- Gasket material
- Carbon tetrachloride
- Paints
  - White for cabinets
  - Black for bases and compressor
  - Thinner
- Cap Screws (cadmium plated)
  - 1/4-inch SAE
  - 1/4-inch USS
  - 5/16-inch SAE
  - 5/16-inch USS
- Lapping compound
- Solder 50-50
- Solder flux (non-corrosive paste)
- Dehydrators and neutralizers
  - Activated alumnia
  - Calcium chloride
  - Silica gel
  - Zinc moss
- Record tags

Electrical supplies
- Wiring
- Conduit — Thin wall ¾-inch and 1-inch
  Electrical
- Fuses — Cartridge
  Plug

The quantity of parts and the kind and amount of supplies kept on hand depend upon the type of work specialized in and the amount of work performed. A careful record should be kept of the amount of stock on hand to insure that a sufficient amount is available to supply all needs.

261. SHOP TOOLS:

Many common tools are necessary to overhaul refrigerating machines efficiently. Some of the tools commonly used in the refrigerating repair shop are:

A complete set of adjustable reamers from ¼-inch diameter up to 1½-inch.

Straight and curved tin snips for cutting gasket material.

A set of hollow punches varying in size from ¼-inch diameter to ⅜-inch for cutting gaskets.

1-quart blow torch for odd heating and soldering jobs.

A halide leak testing torch.

Vises of both the pipe and straight jaw types.

A complete set of socket wrenches equipped with sockets varying from ⅜-inch across flats up to 1½-inch.

Flywheel pullers.

A set of tube benders.

A set of fitting refacers.

Master gauges and thermometers should be used to check the instruments carried by the service men.

A set of adjustable end wrenches varying in size from 6 inches to 12 inches will be found very useful for many different uses.

A set of pipe wrenches varying in size from 6 inches to 12 inches will also be found to be useful.

262. POLICY:

A very accurate record should be kept of all work done and the amount spent on each unit for labor and material. Flat rate charges should be made for compressor overhauls, expansion valve overhauls, and for similar work. When work is brought into the shop, it should be marked as to whether it is to be turned out in a definite time, "rushed," or otherwise. The work upon being completed should be reported and recorded in the proper places so that the units will not be lost or misplaced. The work many be guaranteed for thirty to ninety days depending upon the type of work encountered and clientele built up.

263. REVIEW QUESTIONS:

The answers to the following questions may be found on page 820.

1. List of fittings to be used when one connects a compound gauge having a ⅛ inch pipe male thread to a service valve, having a ¼ inch pipe female thread.
2. When cutting tubing with a hacksaw, what two precautions must one take?
3. What are the S.A.E. thread specifications of ¼ inch, ⅜ inch, and ½ inch tube flare nuts?
4. What is the thickness of refrigeration tubing? (What is the inside diameter of ¼ inch tubing?)
5. Why must the refrigerants be chemically pure?

6. Why must one be careful when handling most refrigerants?
7. Explain the text, "Never use a cheap gas cylinder."
8. What freezing temperature may the weakest domestic brine have?
9. Why is glycerine considered the ideal brine?
10. What safety device is incorporated in a reversible ratchet wrench?
11. What are the two kinds of service repair shops?
12. What may a lathe be used for in a repair shop?
13. Describe the two charging stands in use at the present time.
14. Why is an air dryer necessary in the inlet of the air compressor?
15. Describe the three kinds of lapping blocks or surfaces.
16. Why must a compressor be run at its rated speed when testing it?
17. What is meant by "baking" a compressor?
18. Why is an exhaust fan located near the floor?
19. Why must goggles and rubber aprons be worn when using the acid dip bath?
20. What is the fire hazard in a paint booth? How may it be eliminated?

CHAPTER XIII

COMMERCIAL REFRIGERATION CABINETS AND MECHANISMS

One of the broadest fields of refrigeration is that of commercial refrigeration. This field includes all automatic refrigerating mechanisms other than the domestic or household type. The field that sometimes is confused with commercial refrigeration is the industrial field. This latter field uses those refrigerating machines which need an attendant, usually a licensed refrigeration engineer, on the job constantly. Industrial plants are manually operated refrigeration machines and are commonly used for ice making, large storage houses, packing houses, industrial plants, and ice cream manufacturing plants. Only the commercial field will be studied in this chapter.

264. THE HISTORY OF COMMERCIAL REFRIGERATION:

The first refrigerators used for commercial purposes were small semi-automatic ammonia machines. These machines were used for large meat markets and purposes of a similar nature. These appeared between 1913 and 1915 and filled a very definite need. The mechanism was not totally satisfactory, however, because the installation usually required that a competent refrigerator mechanic or engineer be on the premises, or the owner in some localities was required to have an operator's license. Also the cost of the mechanism was considered to be quite high. When the small domestic machines were first experimented with between 1916 and 1920 the possibility of using them for various commercial purposes was very quickly realized. Soon thereafter the first automatic refrigerators were produced for ice cream cab-

inets (1920-21). Figure 196. These quickly took the place of the old ice and salt mixtures previously used for ice cream storage. The Nizer Corporation of Detroit was one of the first successful manufacturers of this type of machine. This company merged later with Kelvinator, who continued the

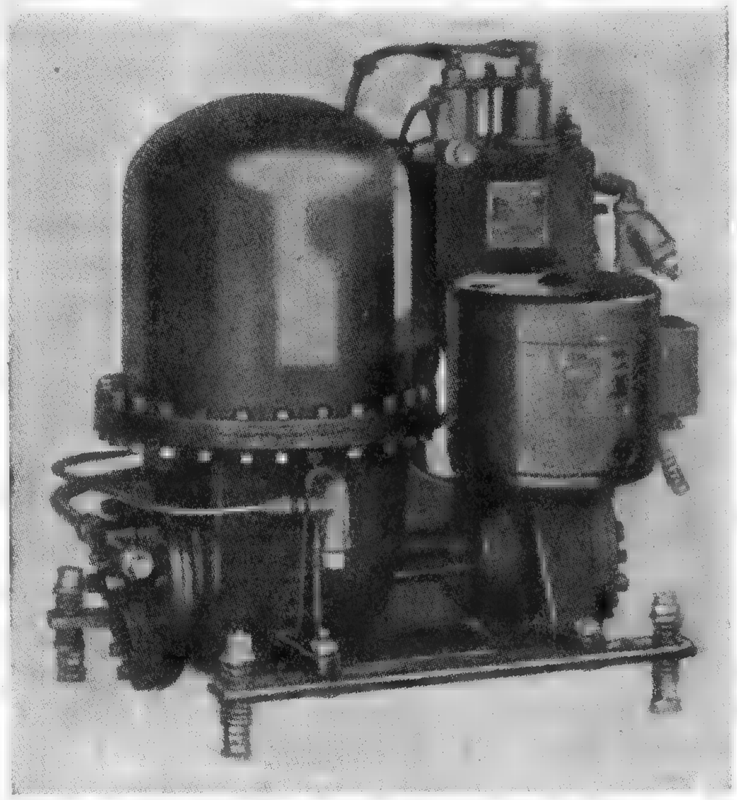


Fig. 196. An early model Nizer condensing unit
(Courtesy of: Kelvinator Sales Corporation)

manufacture of these machines for a short time. The Frigidaire Corporation similarly produced products for this field, followed not long after by the Servel and Copeland companies. The second most important use for commercial refrigeration was for the water-cooling machine and the small

automatic machines for grocery and walk-in refrigerator cabinets. In 1923 mechanical refrigeration made its first real impression on this market, which has grown rapidly since that time. Also the various types of commercial refrigerating equipment have increased and now include such installations as ice cream making, milk coolers, beverage coolers, and air-conditioning. The future field for commercial refrigeration that is holding the attention of manufac-

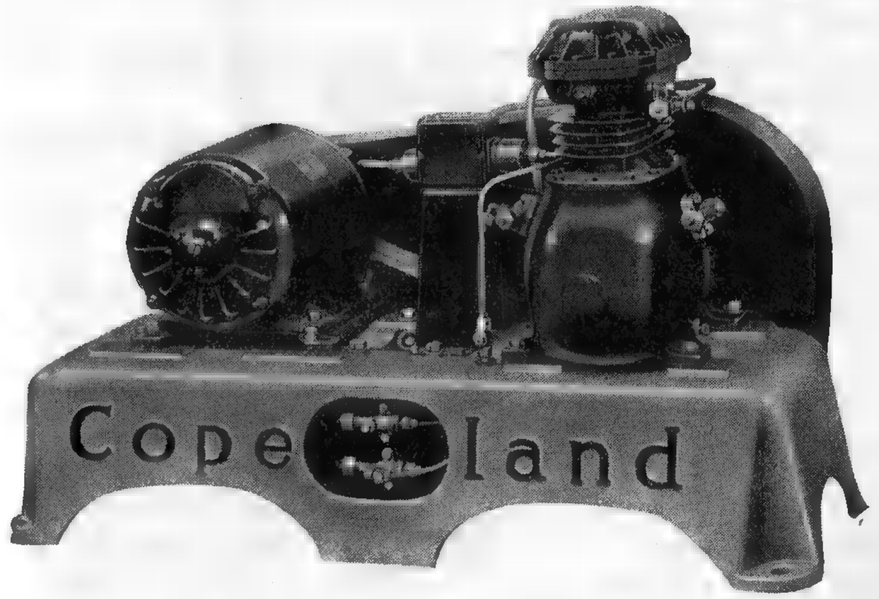


Fig. 197. A modern commercial condensing unit
(Courtesy of: Copeland Sales Company)

turers is the air-cooling and dehumidifying aspect of air-conditioning. The commercial refrigerating machine will play an important part in this development. Figure 197 illustrates a 1934 water-cooled condensing unit suitable for air-conditioning work. Although the future possibilities of commercial refrigeration are hard to predict, the leaders of the industry are very optimistic as to its future. Certainly if

summer comfort cooling becomes popular, the growth of commercial refrigeration will be phenomenal.

265. THE SCOPE OF COMMERCIAL REFRIGERATION:

The commercial refrigeration field covers the following uses: water-cooling, walk-in cabinets, grocery cabinets, display cases of all types, ice cream distribution and manufacturing, trucks, milk cooling, trains, soda fountains, air-conditioning, and laboratory uses.

The three main differences between the domestic and commercial refrigeration machines are:

1. Multiple installations, that is, the same compressor is connected to two or more cooling coils.
2. Water-cooled condensers and compressor heads are usually used.
3. The commercial machines on the average are larger than the domestic machines, and are made up to and including 25 tons of refrigeration capacity.

The mechanism in brief is very similar to the domestic mechanism and includes:

a) compressors
b) condensers
c) liquid receivers
d) cooling units
e) refrigerant controls
f) servicing valves
g) motor controls
h) multiple valves
i) motors
j) water valves

Figure 198 illustrates a typical commercial installation. This installation involves a water-cooled compressor and condenser, driven by a 1 H.P. motor and cooling a walk-in box, a display counter, and a grocery box. As shown, the system has three cooling coils and one condensing unit. To be water-cooled the condensing unit must be connected to a water supply. An automatic water valve regulates the flow of water. The motor will probably be connected to the local

power system through a starting relay and must be installed according to code. A suction line of ½-inch or ⅝-inch O.D. in conjunction with a ¼-inch O.D. liquid line will be run to these cooling units through a steel pipe conduit. Shut-off valves are located at the junctions of the cooling coil lines

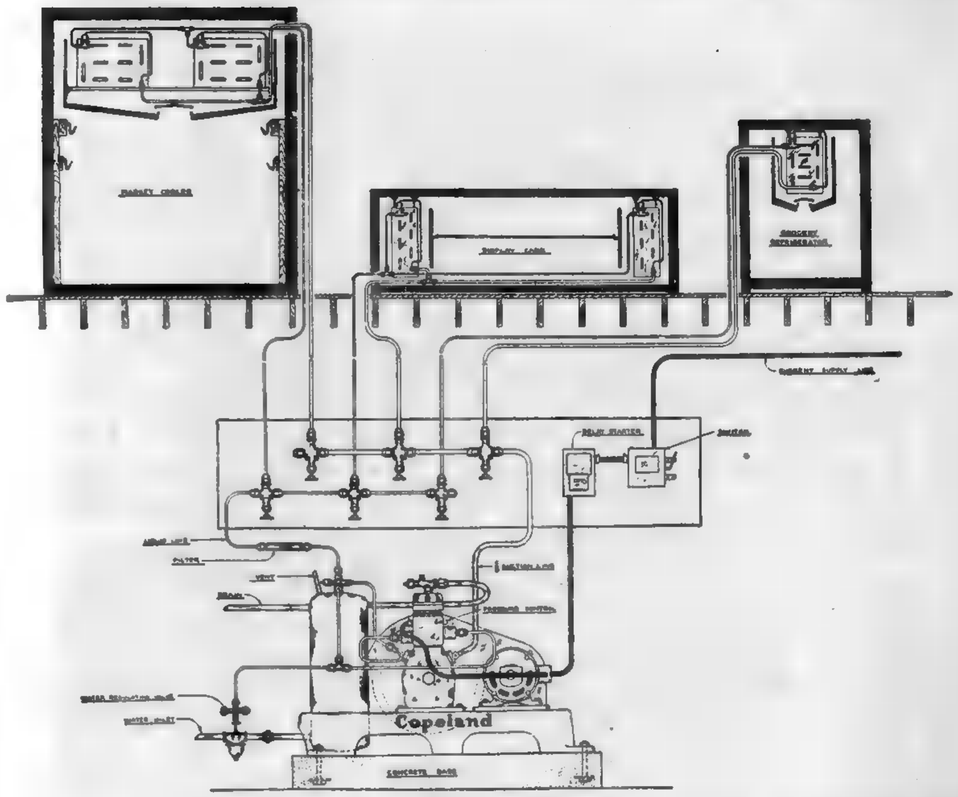


Fig. 198. A typical commercial market installation
(Courtesy of: Copeland Sales Company)

to the main suction and liquid lines. The cooling coils are of special construction for their various purposes; one may find two different kinds of coils used in multiple systems, one using a low side float control and the other using a thermostatic expansion valve. These two refrigerant controls are

the only ones suitable for use in multiple installations. Manifolds with hand shut-off valves are used in these installations; they are usually enclosed in a steel cabinet or box.

266. COMMERCIAL CABINET CONSTRUCTION:

Inasmuch as commercial refrigeration covers a considerable number of applications, a study of the various cabinets used in these applications is necessary. There are many different sizes, shapes, and styles of cabinets used for a number of different applications. Some classifications are: grocery cabinets; grocery display counters; walk-in boxes for storage purposes, fresh meat preservation and for beverage and milk storage purposes; display counters for meats of all kinds, including a special type for fresh fish, also a type which uses the lower part of the display counter for storage purposes; apartment house refrigerator cabinets; ice cream cabinets; soda fountains in which compartments of different temperatures are maintained; water-cooler cabinets or fountains which must have a peculiar style of construction to facilitate insulation; motor trucks whose bodies must be of insulated construction to produce economy of refrigeration; and railway trains of refrigerated cars of special refrigeration construction. A recent refrigeration problem that is still unsolved satisfactorily is the display of very cold or frozen foods.

267. GROCERY CABINETS:

Grocery cabinets have been used for many years to keep perishable produce and groceries at satisfactory temperatures. Early cabinets used ice as the means of refrigeration, but thousands of these have been converted into mechanical refrigeration cabinets since the advent of mechanical refrigeration. These cabinets are usually of the reach-in type with small doors opening so that one may gain access to any shelf

inside the box. Some of these doors are fitted with windows. The number of doors varies from two doors up to eight doors, with one door used especially to gain access to the cooling unit. Figure 199. The space which contains the cooling unit is usually called the bunker. This terminology comes from

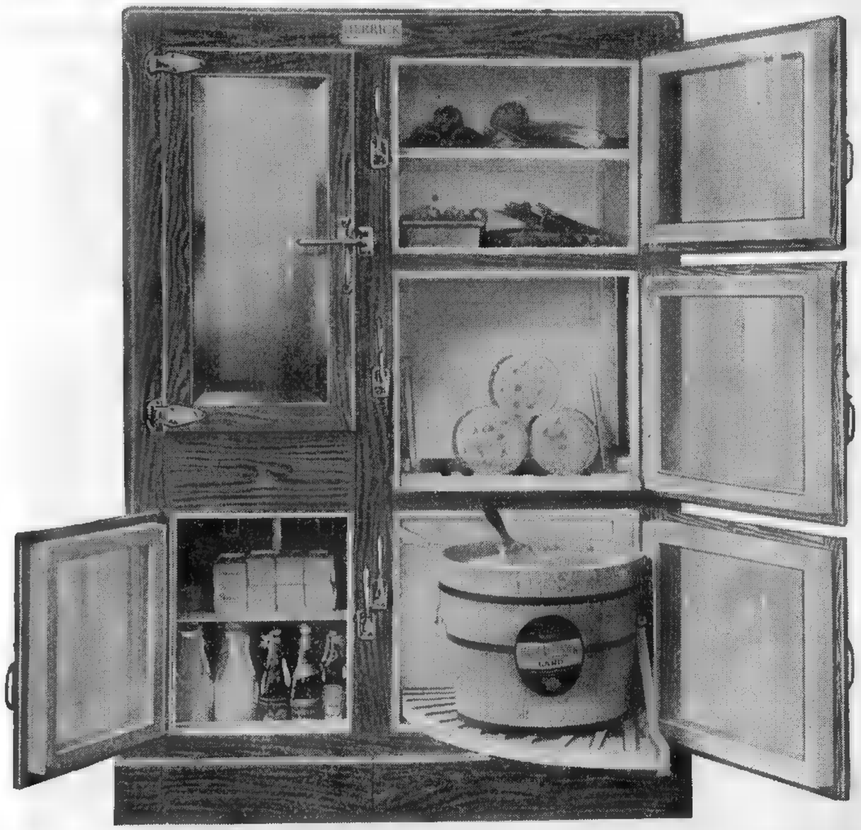


Fig. 199. A grocery cabinet with the coil bunker in the upper left-hand corner
(Courtesy of: Herrick Refrigerator Company)

the original use of ice in these cabinets. These bunkers are sometimes located in the upper left hand corner of the box, or in the upper right hand corner and sometimes completely across the top of the inside of the cabinet. This latter type sometimes uses a door located at the end of the cabinet for

means of access to the bunker. The early box construction was hard wood, oak, maple or similar wood on the outside. The later models are constructed with a porcelain exterior. While the inside of the early cabinet used spruce or some other similar wood as a lining, the modern models have a porcelain lining. The insulation most commonly used for these boxes is 2 inches of slab cork. Early cabinets used moisture-proof paper and dead air spaces. The size of these

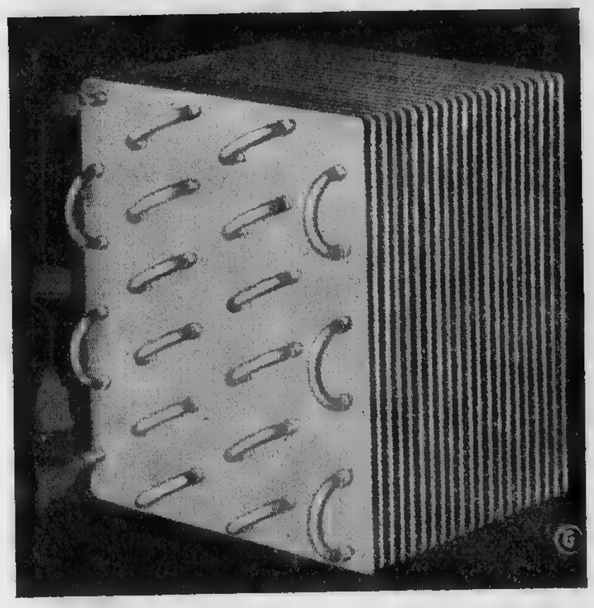


Fig. 200. A typical grocery cabinet "dry" coil
(Courtesy of: Larkin Refrigerating Corporation)

boxes varies considerably with 10 to 15 cubic feet interior net volume being quite common. The temperatures desired are the same as in domestic boxes with a minimum of 40°F. and a maximum of 50°F. The coil is usually located in the upper center of the cabinet; the old flooded coils used a few deep fins while the new coils are deep finned 1½-inch spacing coils, using a thermostatic expansion valve. The coils are suspended from the top. Figure 200.

268. WALK-IN COOLERS:

Meat markets usually have a refrigerated cabinet or walk-in cabinet in which to store meat and other perishable products. These cabinets have large doors and windows and are sometimes classified as butcher boxes. The size of these cabinets

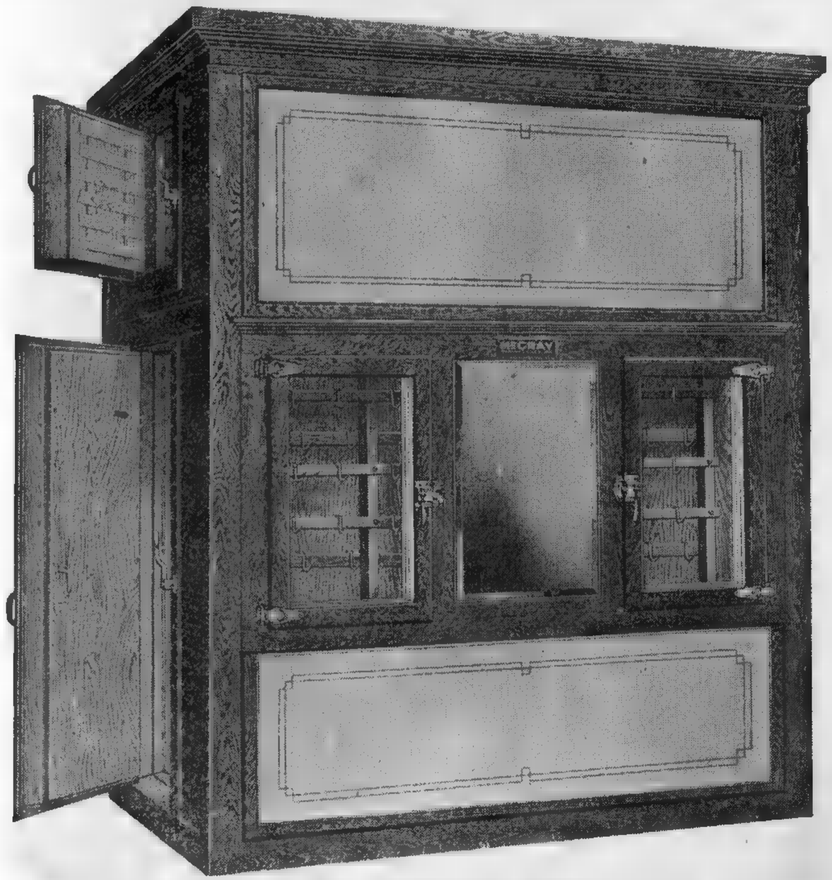


Fig. 201. A walk-in cooler
(Courtesy of: McCray Refrigerator Sales Corporation)

varies to quite an extent, but two heights are standard; 9 feet 10 inches or 7 feet 6 inches exterior dimension. These boxes are called the "knock-down style" which means that they may be taken apart for ease in removing.

Some standard walk-in cooler sizes are:

L.	W.	L.	W.
7′ x	5′ x 9′10″	6′ x	5′ x 7′6″
8′ x	6′ x 9′10″	6′ x	6′ x 7′6″
8′ x	8′ x 9′10″	7′ x	6′ x 7′6″
9′ x	7′ x 9′10″		
12′ x	10′ x 9′10″		

Fig. 201A. A porcelain exterior walk-in cooler
(Courtesy of: McCray Refrigerator Sales Corporation)

Early walk-in coolers were made with oak, maple, or other hard wood exteriors, and spruce linings. The insulation consisted of 3 to 4 inches of cork placed between the inside and outside surfaces. Figure 201. At present these boxes are being made with metal linings and porcelain finished ex-

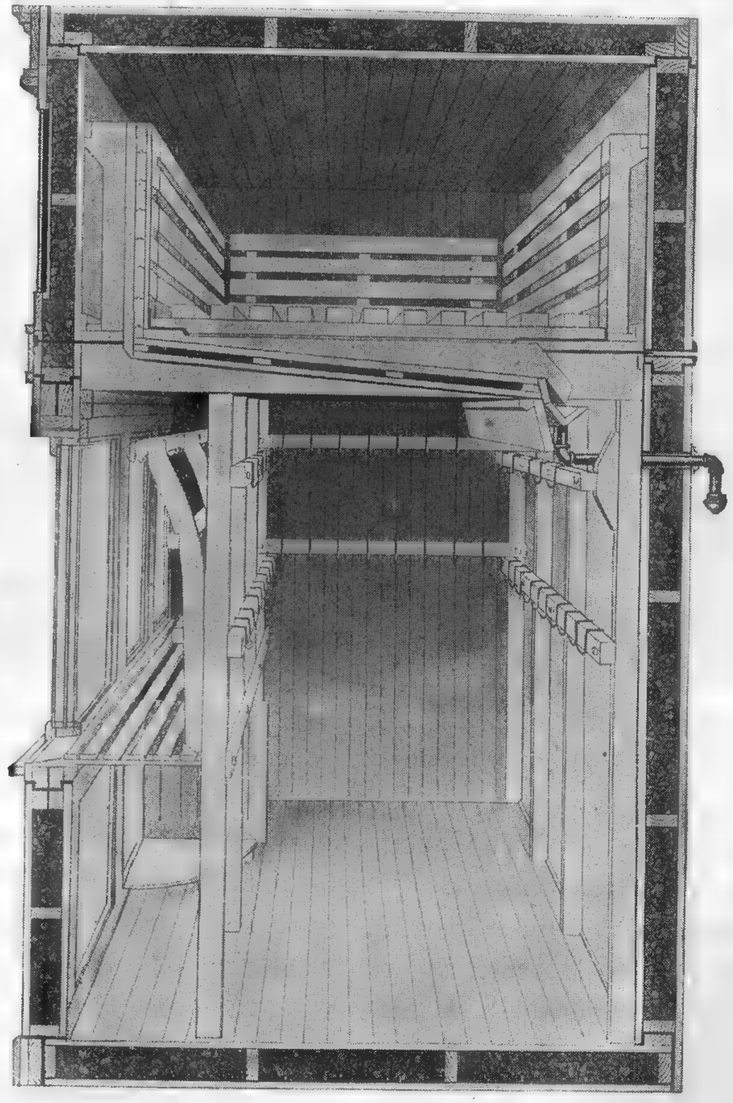


Fig. 202. The interior of a walk-in cooler
(Courtesy of: McCray Refrigerator Sales Corporation)

teriors. They are standardized according to their ability to keep out heat. Grade A specifies a maximum of 3 B.T.U. per °F. per square foot per day. The door is usually made of the same construction as the box and is gasketed to make it air-tight. These gaskets are usually made of built up rubber. Door latches for these cabinets must also be accessible from the inside. In addition to the entrance doors, these boxes are equipped with small reach-in doors, usually with double or triple glass. That is, instead of having a cork lining, these doors have two or three panes of glass arranged in such a way that they are air-tight, and for one or two air spaces respectively between them. Plate glass is usually used; special chemicals, such as calcium chloride, are used to keep the spaces between the panes free from moisture.

The cooling unit for these boxes is usually mounted overhead inside the cabinet, with a baffle constructed to promote good air circulation around it. (See Paragraph 336.) An overhead bunker door is provided to permit one to get into this space. Its size is standardized at 27 inches wide minimum and 28 to 36 inches high. Figure 202. Some of these walk-in coolers have a side mounted cooling unit which has a vertical baffle located between it and the main portion of the cabinet interior. Recently, forced convection cooling units have been used in these cabinets, as such an installation eliminates any need for a baffle. (See Paragraph 292.) The temperature maintained in this type of cabinet depends upon the use. For meat storage or fresh produce storage, a temperature of between 35°F. and 40°F. is essential and a relative humidity of about 80 per cent should be kept. For milk storage, beer cooling, and other service in which the dehydration of foods is not important, colder temperatures may be used as desired and less attention may be paid to relative humidity. The natural convection cooling coils used in these

cabinets usually use ½-inch fin spacings and vary between 6 inches to 16 inches in depth. (Figure 203.)

269. FLORISTS' CABINETS:

Florists' cabinets vary in size and construction; they differ from grocery cabinets and walk-in coolers in three ways. First, the temperatures within the cabinet may be kept much

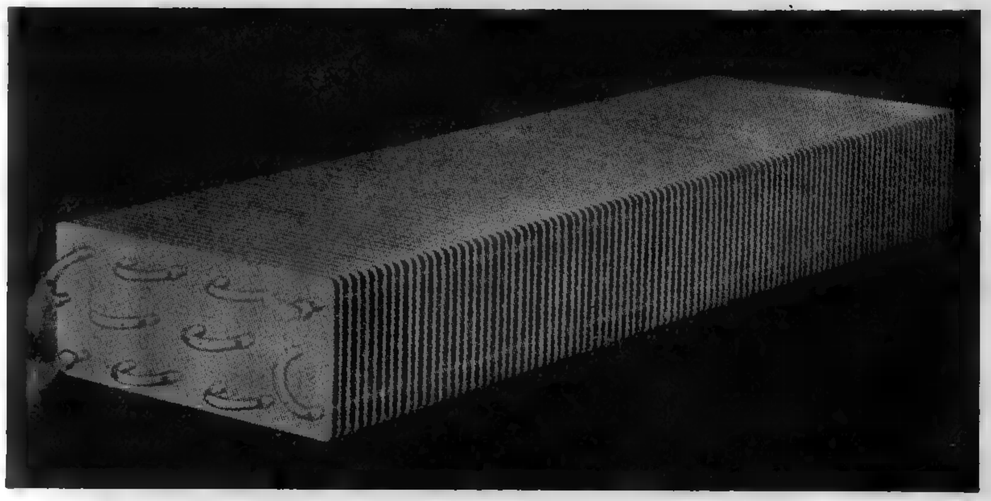


Fig. 203. A walk-in cabinet cooling coil
(Courtesy of: Larkin Refrigerating Corporation)

higher than those in the other types of boxes. Temperatures between 55°F. and 58°F. are quite common. Second, the thickness of the insulation for these cabinets, as a result of the lesser temperature difference, is usually but 1 to 2 inches thick. Third, these cabinets are made with an extensive amount of window surface, permitting an easy display of cut flowers within the cabinet. Figure 204. Humidity is an important factor in a florist's cabinet, and should be kept as high as possible in order to retard evaporation from the surface of the leaves and flowers.

270. DISPLAY CASES:

To display produce to the best advantage, stores frequently use a refrigerated counter. These counters are equipped with

Fig. 204. A florist's cabinet
(Courtesy of: McCray Refrigerator Sales Corporation)

glass fronts, enabling the purchaser to see the array of articles handled by the merchant; at the same time this food is safely refrigerated. This refrigeration is necessary to prevent the spoiling of the food during the 8 to 10 hour period

that it is stored in the display case. Electric lights for lighting display cases are usually installed outside of the glass of the case in order that the heat generated by the lights will not increase the refrigerating load.

271. REAR BUNKER DISPLAY CASE:

The most popular of the display cases is the full vision rear bunker type. The top of this case has a display space formed

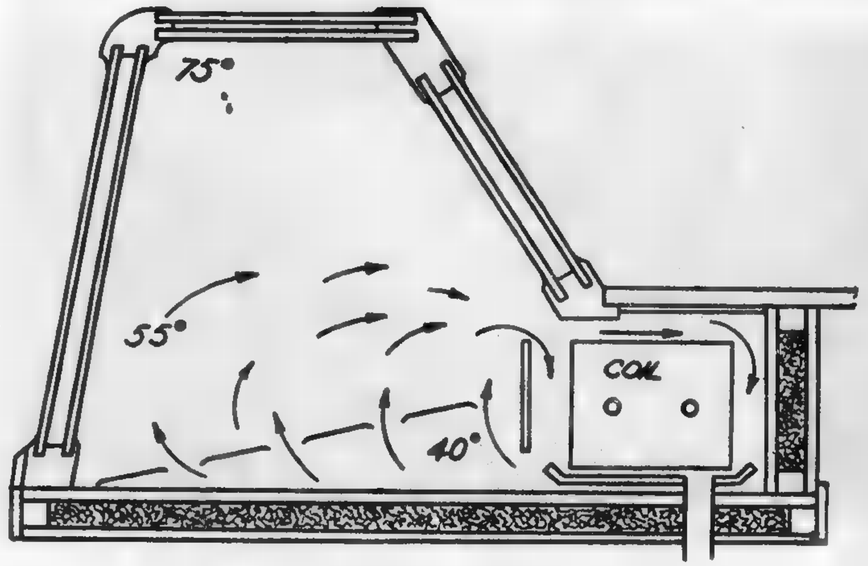


Fig. 205. A rear bunker display case

by a glass front and a sliding door in the rear. The bottom of this case is an ordinary counter; it forms a space in which articles may be kept and is open at the back. The floor of the refrigerated space is insulated with approximately ▮ inches of cork. The front is formed of two or three panes of glass at an angle from the vertical to permit easy inspection of the goods within. Figure 205. The top consists of a shelf in which display lights are mounted and the rear wall con-

sists of sliding doors, also equipped with two or three panes of glass. These counters commonly come in 6, 8, 10, and 12 foot lengths. Just below the sliding doors there is a compartment which is level with the bottom of the display space. This is a bunker built into the cabinet to house the cooling coils. These cooling coils are usually kept about 26°F. to 27°F., permitting temperatures on the lower shelf of the display case of about 40°F., but because of the fact that warm air rises, the upper portion of the case has tempera-

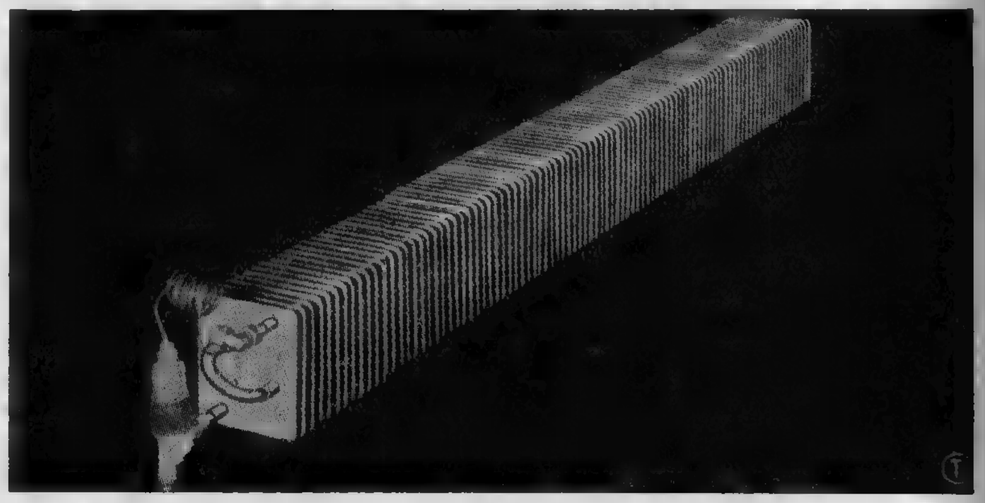


Fig. 206. A cooling coil for a rear bunker display case
(Courtesy of: Larkin Refrigerating Corporation)

tures very close to room temperatures. This type of display counter was developed originally for the use of ice as the cooling medium. The coils used in these rear bunker display cases are illustrated in Figure 206.

272. OVERHEAD BUNKER DISPLAY CASE:

A display counter, which is rapidly coming into favor, is the type using an overhead cooling coil. This counter frequently

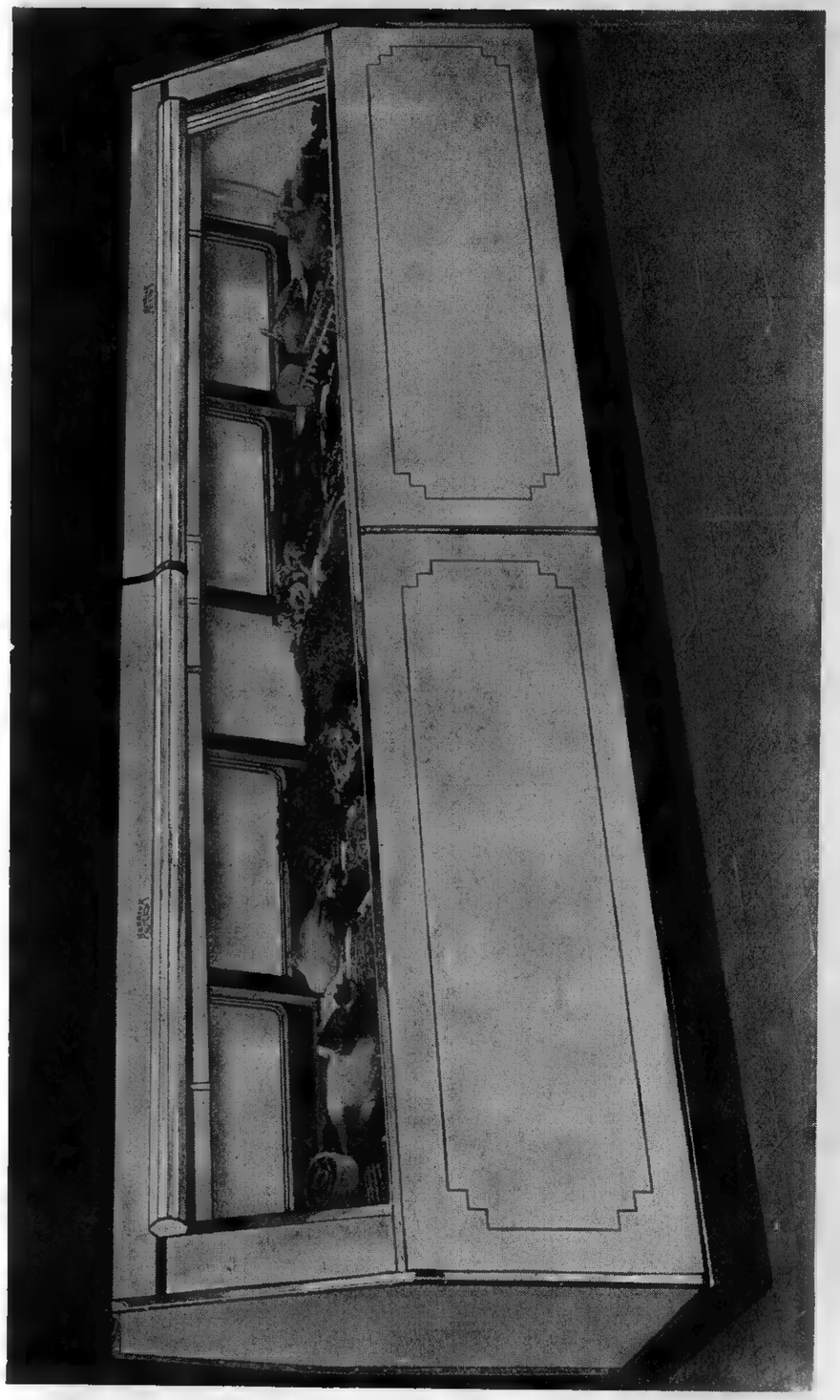


Fig. 207. A display case with an overhead cooling coil
(Courtesy of: Herrick Refrigerator Company)

makes use of the space below the display portion as a refrigerator cabinet. This counter has the main cooling coils mounted in the upper portion of the display space just underneath the shelf which forms the top of the counter. This naturally gives very good refrigerating temperatures all the way through the display space. Figure 207. In addition, some of this type of counters have shelf coils. These cooling coils are located just underneath the shelves; they consist of coils of tinned tubing containing evaporating refrigerant so placed that each shelf is individually cooled.

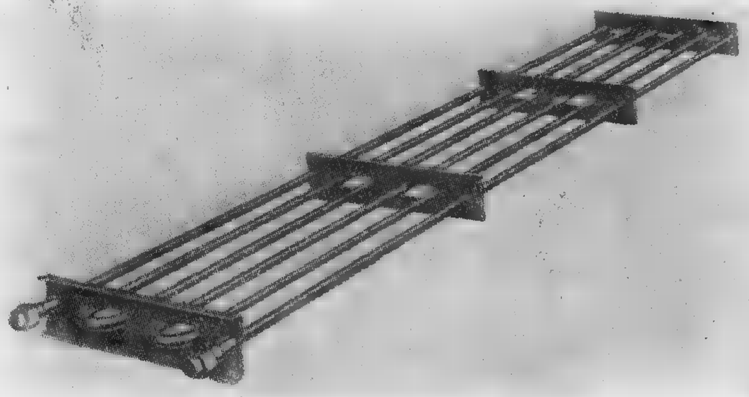


Fig. 208. A shelf cooling coil
(Courtesy of: Kelvinator Sales Corporation)

The store space beneath the display portion of the counter is also refrigerated; its cooling coil is usually connected in series with the coils above. The temperatures maintained may be kept at 40°F. to 45°F. in both compartments, or warmer if desired, because they are only temporary containers for the food or produce as it should be transferred to the walk-in storage cabinet overnight. The coils used in these installations must necessarily be very narrow and they are made with fins as small as 1¼ inches in width. Some of the shelf coils are the plain tubing type. Figure 208.

273. END BUNKER DISPLAY CASE:

Another type of display counter used to some extent is the end bunker type. Instead of using cooling coils running the

Fig. 209. End bunker display case
(Courtesy of: Herrick Refrigerator Company)

full length of the counter, the coils are located at each end. If the counter is 7 feet long or less, it may have but one bunker at the end or at both ends if the counter is longer.

Figure 209. These counters vary from 35 to 45 inches in height and the glass extends to the floor. The space within usually contains from two to four shelves which may be viewed either from the front or the top of the case. Sometimes the glass is inclined in front, but more often is vertical. The temperatures that are kept in these counters are between 40°F. and 50°F. A coil similar to the grocery cabinet coil is used in these cases.

274. APARTMENT HOUSE CABINETS:

There is very little difference between domestic and apartment house cabinets. Reference to domestic refrigerator cabinets in Chapter IX will give details of the construction of these cabinets. The cabinets are usually fastened down permanently and very often they are built into the kitchen ensemble. Domestic box temperatures of 40°F. to 45°F. are desired.

275. ICE CREAM CABINETS:

Ice cream cabinets, since their inception, have been made of ■ steel framework with a sheet metal exterior, insulated with approximately 4 inches of cork and containing either a brine tank or dry coils surrounding the ice cream sleeves. The size of the ice cream tank holders, or sleeves as they are called, is standardized; therefore the construction of the various makes of cabinets is very similar. The insulation is usually 4 inches thick, except on the top, which is commonly ■ inches thick. Slab cork is the most popular insulation and is very carefully sealed with hydrolene. Ice cream cabinets ■■■ sometimes self-contained, meaning that the refrigerating machine or condensing unit is built into one end of the cabinet. However, many of them are of the remote type. Figure 210 illustrates an early type self-contained ice cream cabinet. The size of these cabinets is based upon the number of sleeves required to contain the bulk ice cream cans, and they range from one to twelve sleeves. The temperature at which the ice cream should be kept is between 0°F. and 10°F. The 0°F. is for the brick ice cream which may be stored in these sleeves and 5°F. to 10°F. is best for the bulk ice cream. If the temperature is too cold, the ice cream becomes too hard to serve easily; it also tends to become crystallized. The

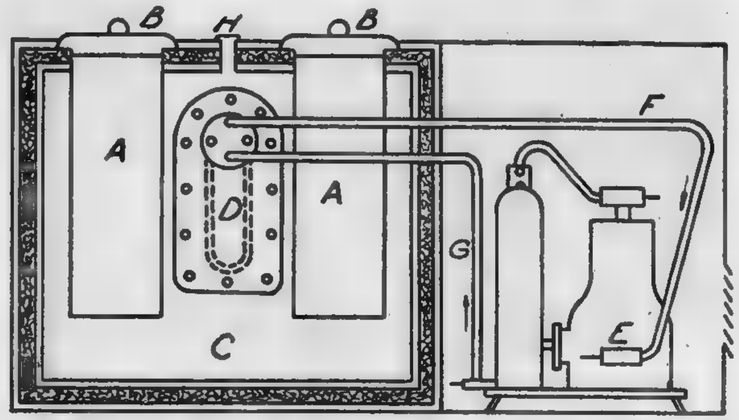


Fig. 210. A self-contained ice cream cabinet using ■ flooded cooling coil
A. Ice cream sleeves; B. Lids; C. Brine; D. Cooling coil; E. Compressor; F. Suction line; G. Liquid line; H. Brine filler plug

cooling units in the past were of the low side float type submerged in brine, which surrounded the sleeves keeping the ice cream cold. However, this was bulky and inconvenient in many respects so that present models use dry cooling coils, and the coils themselves consist of tinned tubing wrapped around and soldered directly to the sleeves. Figure 211. The sleeve covers, that is, the tops to the sleeves which must be raised in order to gain access to the ice cream, are also standardized by the refrigerating companies and need no

explanation. Having the openings to these sleeves at the top prevents the spilling of cold air from the cabinet, when opened, and is an easy way of access.

276. SODA FOUNTAINS:

Soda fountains are a very compact unit for the storing and

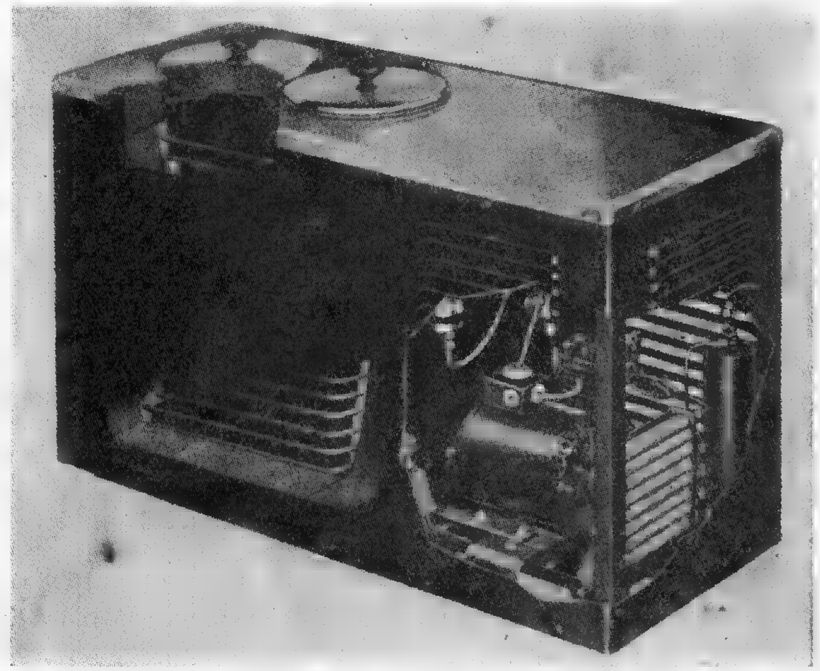


Fig. 211. An ice cream cabinet using a dry cooling coil
(Courtesy of: Kelvinator Sales Corporation)

dispensing of ice cream, water, beverages, syrups, and ice. They are usually of a very beautiful construction and are designed to facilitate dispensing. Figure 212 illustrates a two cooling coil installation; note the various temperatures maintained at the fountain. The fountain usually has an ice cream cabinet of typical design built into it which is practically the same as described above. Another portion of the

fountain contains the water-cooling mechanism which must be built especially to maintain correct water temperatures; usually the return of refrigerant gas from the ice cream cabinet and the drinking water cooler is passed around the syrups, maintaining them at a relatively cool temperature. The beverages are kept at the same temperature as the water.

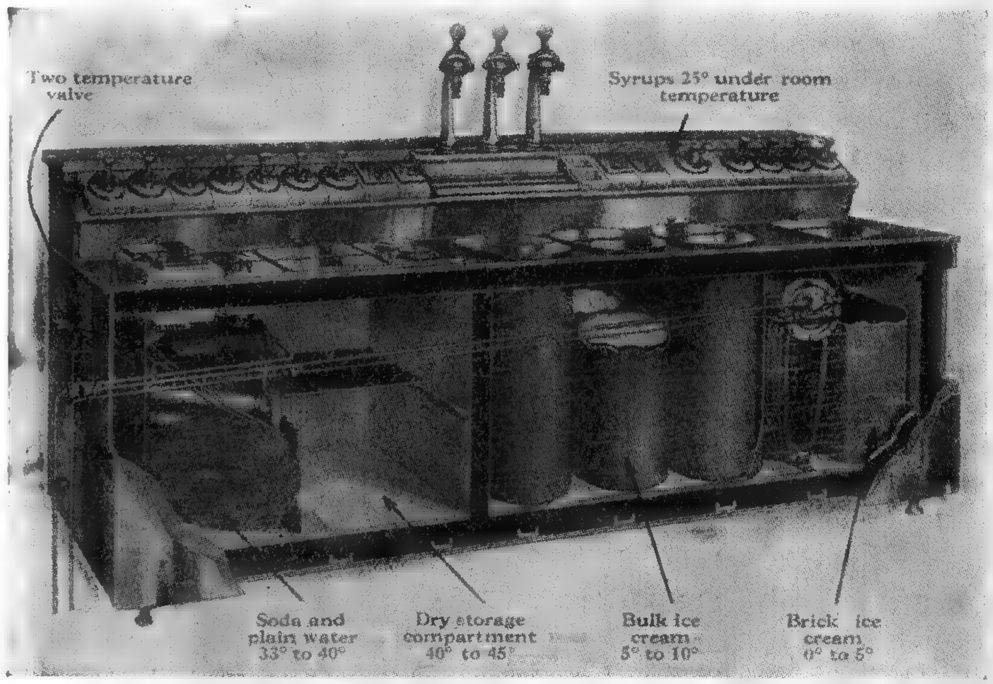

Two temperature valve
Syrups 25° under room temperature
Soda and plain water 33° to 40°
Dry storage compartment 40° to 45°
Bulk ice cream 5° to 10°
Brick ice cream 0° to 5°

Fig. 212. A soda fountain refrigeration installation
(Courtesy of: Kelvinator Sales Corporation)

The coils carrying these beverages are all submerged in a tap water bath which in turn is cooled by a refrigerating coil also submerged in it. Figure 213. Frequently, soda fountain construction sacrifices facilities to servicing for appearance. As a result, soda fountains are often very difficult to service. The syrups should be maintained about 45°F., the

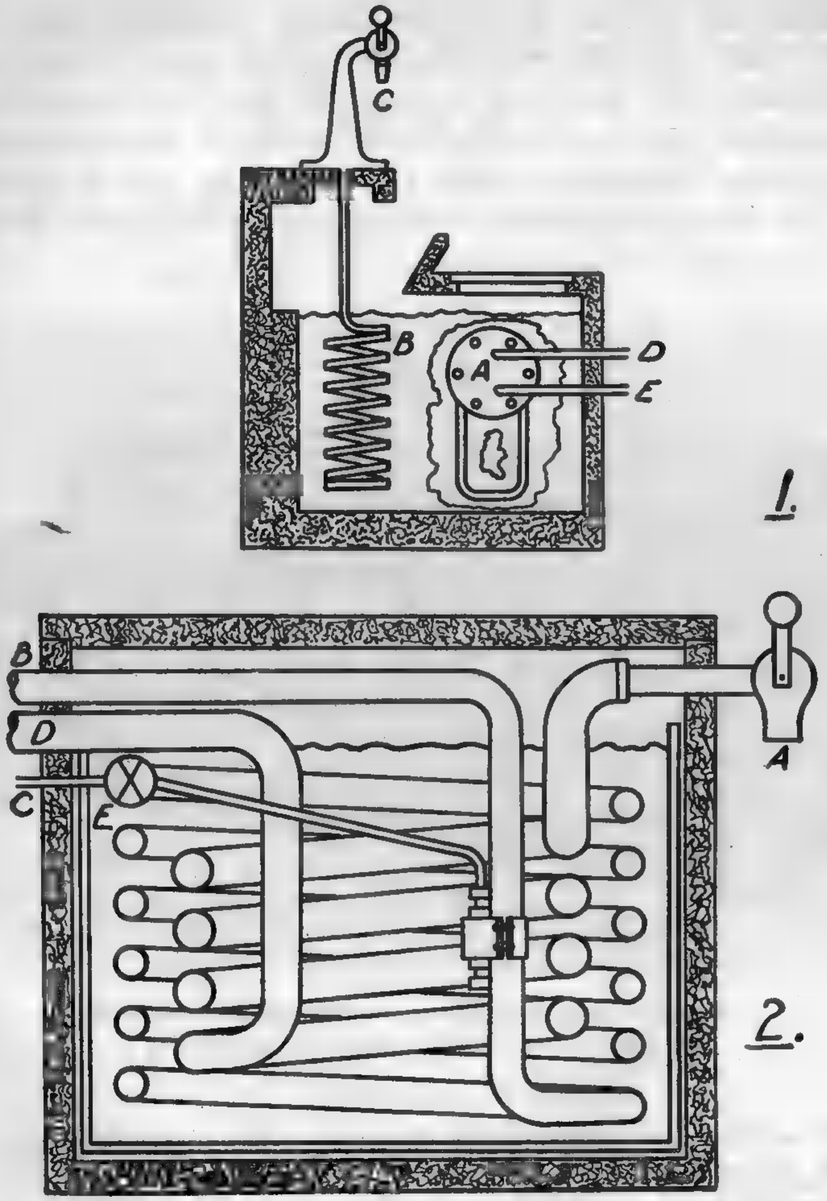


Fig. 213. Beverage cooling coils using sweet water baths
1. Flooded coil; A. Cooling coil; B. Beverage coil; C. Tap; D. Suction line; E. Liquid line; 2. Dry coil; A. Tap; B. Suction line; C. Liquid line; D. Beverage in; E. Thermostatic expansion valve
(Courtesy of: Universal Cooler Corporation)

water anywhere from 32° to 50°, and the ice cream as mentioned between 0°F. to 10°F. A two-temperature valve is almost a necessity in this type of installation. See Paragraph 302.

277. WATER-COOLERS:

There are really no cabinets used for the containing of water-cooling mechanisms in the strict sense of the word. The so-called cabinets are a sheet metal housing built around a steel framework, to give a pleasing appearance to the fountain. Inside this sheet metal housing is usually constructed the condensing unit, located near the floor, and above this is the water-cooling mechanism. This is the only part insulated from the room. The insulation is usually specially formed slab cork between 1½ inches and 2 inches thick. These cabinets are made in such a way that one or more sides may be easily removed to gain access to the interior. Figure 214. A recent trend in individual water-coolers is the use of heat exchangers. These make use of the low temperature of the waste water and the suction line to pre-cool the fresh water line to the cooling coil. The temperatures of the cooling water are variable depending on the wishes of the persons who are drinking the water. For laborers in heavy working conditions 50°F. to 55°F. is cold enough. Refer to Figure 279 for recommended temperatures. One must be careful to use clean materials for the water passages. In large business establishments, in office buildings, or in factories, the multiple water-coolers, instead of individual ones, are the most popular. These coolers have one large condensing unit supplying many bubblers and these are of many different constructions.

278. REFRIGERATED TRUCK BODIES:

The construction of truck bodies for refrigeration purposes is not entirely solved, and there are many types in use at the

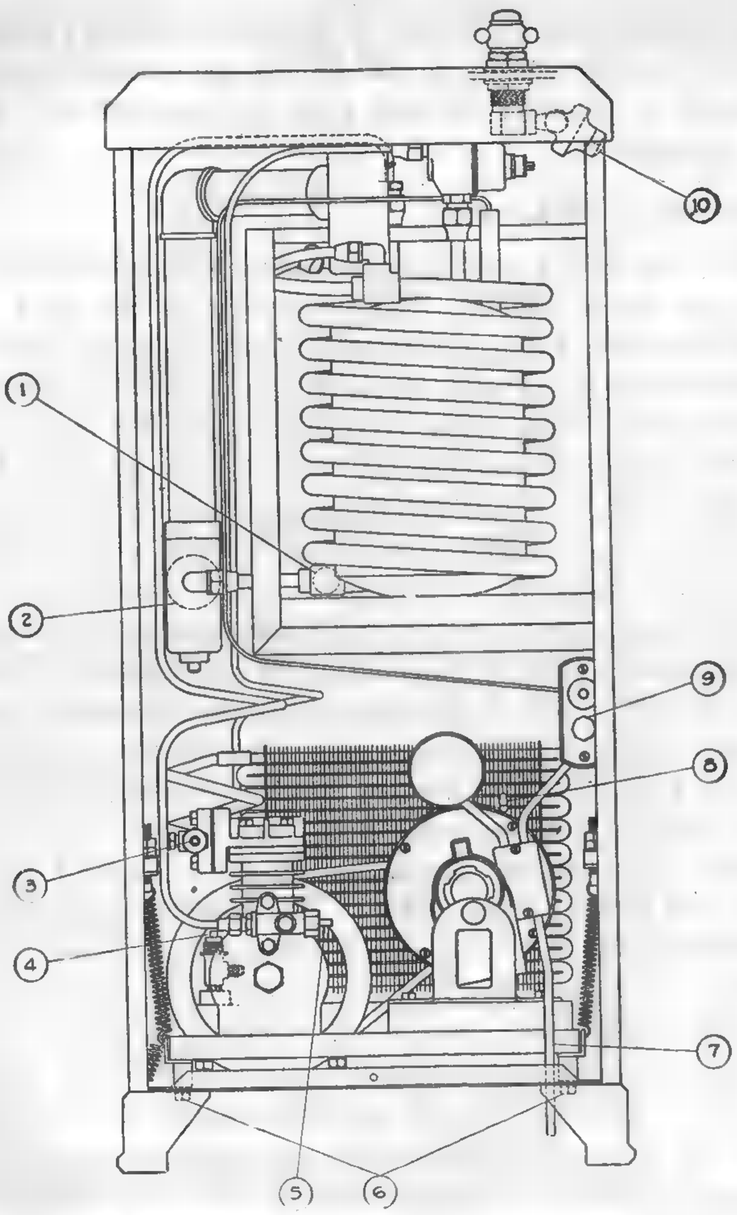


Fig. 214. A self-contained water cooler
1. Water supply; 2. Drain; 3. D.S.V.; 4. L.R.S.V.; 5. S.S.V.; 6. Hold down bolts; 7. Electric connections; 8. Oil cups; 9. Motor control; 10. Water flow adjustment
(Courtesy of: Halsey W. Taylor Company)

present time. The construction, of course, must be light but sturdy so that continual vibration and rough handling will

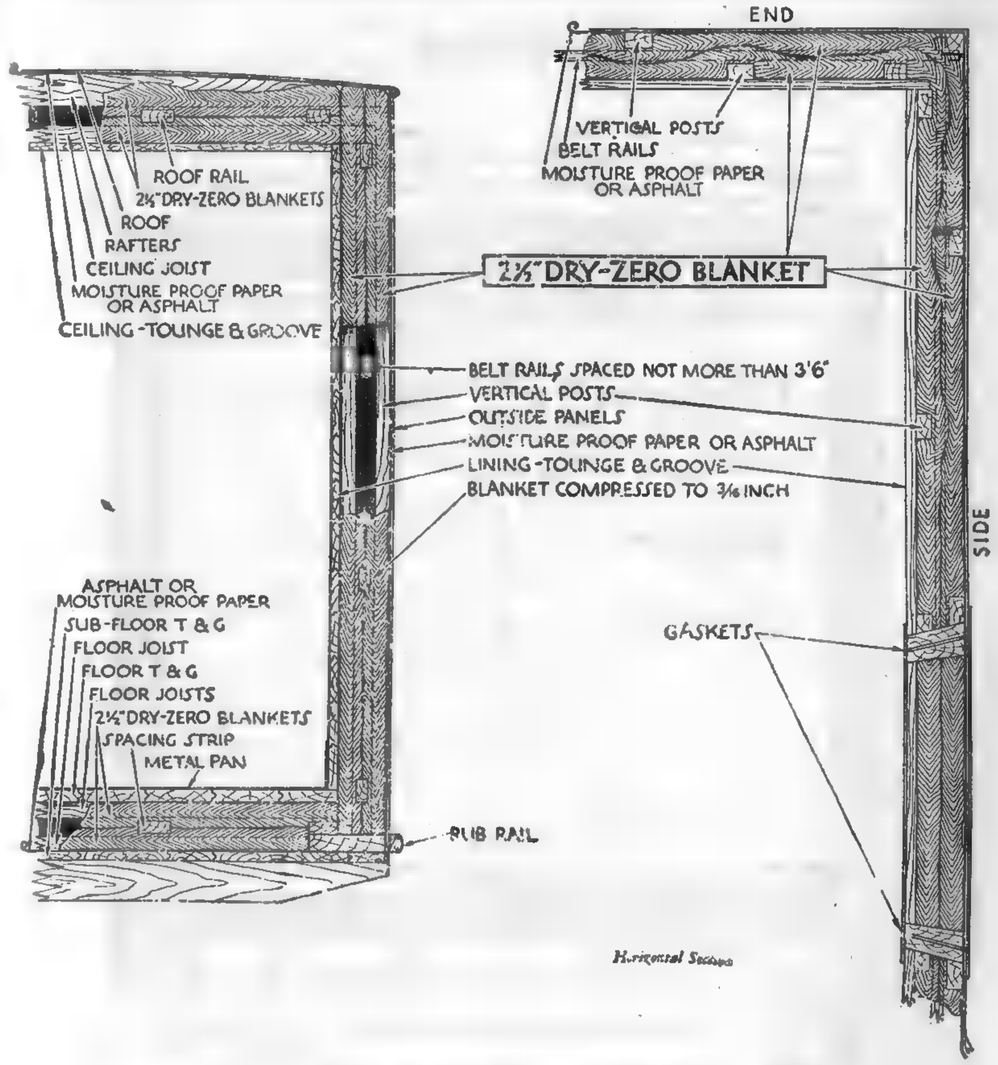


Fig. 215. A refrigerated truck body
(Courtesy of: Dry Zero Corporation)

not destroy the insulating value of the walls. Various insulating materials have been used. Figure 215. One insulation

that has great possibilities is the metal foil type explained in Paragraph 136. The most interesting things about truck refrigeration are the styles and mechanisms used. These are

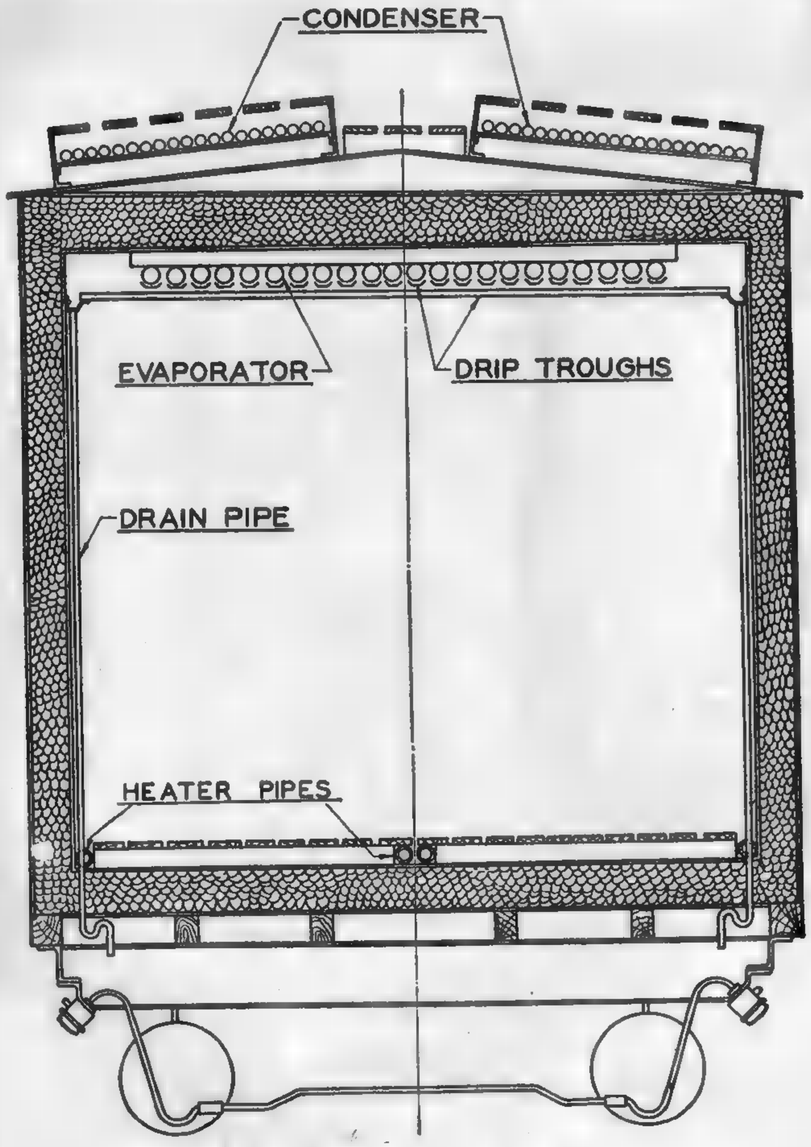


Fig. 216. A refrigerated railroad car construction
(Courtesy of: Safety Refrigeration Inc.)

discussed in Paragraph 317. Because of the many uses of truck refrigeration, the desired temperatures naturally vary, therefore each problem must be studied before a temperature may be recommended. Dry-ice trucks must be insulated for —109°F.; ice cream trucks for 0°F. to 5°F., while other commodities often use 35°F. to 40°F. temperatures.

279. REFRIGERATED RAILWAY CAR CONSTRUCTION:

Refrigeration cars have long been used as a means of transporting perishable goods. However, these cars used ice and sometimes salt and ice mixtures as the refrigerating medium. Recently, however, to obtain colder temperatures and to permit faster loading of the cars, mechanical refrigeration has entered this field. As far as the cars themselves are concerned, the construction is very similar to that of the ice car construction, except that the builders are continually seeking to reduce the weight of the car. Figure 216.

In order to attack any commercial refrigeration problem correctly, one must first determine all of the requirements concerning the job to be done; next specify, install, and adjust the mechanism to obtain the correct operation. Basically the requirements are to maintain certain temperatures and frequently certain humidities in storage spaces. How it is done is not so important as that it is done economically and consistently.

280. CONSTRUCTION OF THE REFRIGERATING MECHANISM:

The same fundamental types of cycles are used in commercial refrigeration that are used in the field of domestic refrigeration. These are the mechanical cycle and the absorption cycle. The absorption cycle will not be treated in this par-

ticular part of the text, inasmuch as commercial absorption installations are all individual. The construction and operation of them is very similar to the ones studied in Chapter VI. These absorption machines are used for water-cooling, ice cream cabinets, and other smaller commercial applications. The mechanical cycle and mechanism vary from that of the domestic cycle mainly in the multiplicity of cooling units connected to one condensing unit. The following treats of the details of construction of the various mechanical commercial refrigerating machines.

281. THE MECHANICAL CYCLE:

Most of the commercial refrigerating apparatus is of conventional design (completely serviceable), but many of the single applications such as bottle coolers, beverage dispensers, and ice cream cabinets are constructed in the hermetic style, using an apparatus very similar to the designs shown in Chapter V, except that the cabinet varies according to the application. The conventional refrigerating machine is composed fundamentally of parts very similar to those of the domestic machine. The unit is constructed to vaporize a refrigerant under a controlled pressure in a cooling coil. The gas formed is then passed to the condensing unit which removes the heat from the gas and reconverts it into a liquid. Only two pressures are needed, the vaporizing pressure (low) and the condensing pressure (high) (Paragraphs 36, 37 and 38).

282. THE COMPLETE MECHANICAL MECHANISM:

The single unit commercial refrigerating mechanism apparatus consists of:

A. The high pressure side:
   1. The compressor
   2. The condenser (usually air-cooled)
   3. The liquid receiver
   4. The high pressure safety motor control
   5. The liquid line

B. The low pressure side:
   1. The refrigerant control (thermostatic expansion valves or lowside floats)
   2. The cooling unit
   3. The low pressure or temperature motor control
   4. The suction line

The multiple mechanical mechanism consists of:

A. The high pressure side
   1. The compressor
   2. The condenser
      a) Water-cooled or air-cooled
   3. The liquid receiver (with an air-cooled condenser. or with a tube within a tube condenser)
   4. The high pressure motor control (safety)
   5. The liquid line (with a distributing manifold)
   6. A water valve (used with a water-cooled unit)

B. The low pressure side
   1. The refrigerant controls (two or more which may be either of the low side float or the thermostatic expansion valve construction)
   2. The cooling units (two or more which may be of the natural convection, forced convection, or submerged in brine types)
   3. The motor control (which is usually of the pressure type)
   4. The suction line with a suction line manifold.

5. Two-temperature valves (for multiple temperature installations)
6. Surge tanks (for absorbing pressure fluctuations)
7. Check valves (for multiple temperature installations)

283. THE COMPRESSOR:

The typical commercial compressor is of vertical reciprocating construction, made of one or more cast-steel nickel-alloy cylinders which use cast-iron pistons driven by means of a drop forged connecting rod and a hardened steel, full-floating piston pin. The connecting rod is usually attached to a crank throw type of crankshaft which is drop forged and case hardened. The bearings are typically bronze alloy. Main bearings are made of a similar material although some companies use the crankcase material for main bearings. The crankshaft seal may be of the type wherein the bellows is stationary and presses against a crankshaft shoulder, or may be of the type where the bellows is sealed to the crankshaft and revolves with it. Until recently the oiling of the compressor has been done by the splash system, but the present trend is toward a force-feed lubrication to all moving parts.

The compressors usually have a double cylinder head. The intermediate one carries the exhaust valves. The cylinder heads are made of the same material as the cylinder body, although some companies make the intermediate one of steel plate. Figure 217. The intake valves and the exhaust valves are made of very thin spring steel, similar to those used in the domestic models. This design, however, changes with the size of the unit. Large compressors use multiple disks and port openings instead of the single opening employed in domestic work. The intake valve is usually located in the

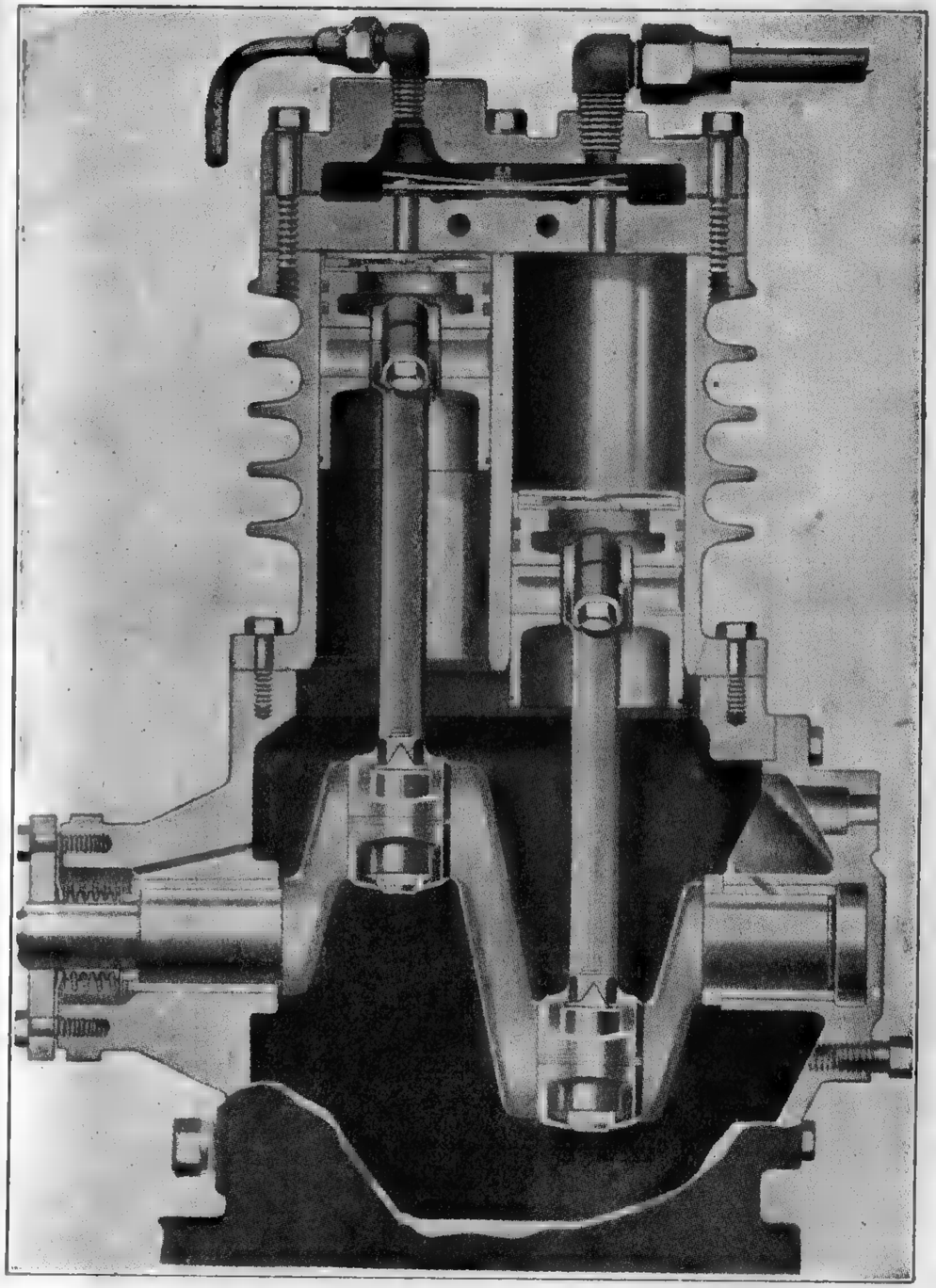


Fig. 217. A water- and air-cooled commercial compressor
(Courtesy of: Frigidaire Corporation)

piston, but their design varies with practically every manufacturer.

Practically without exception the pistons are equipped with two or more rings. The clearances permitted for all

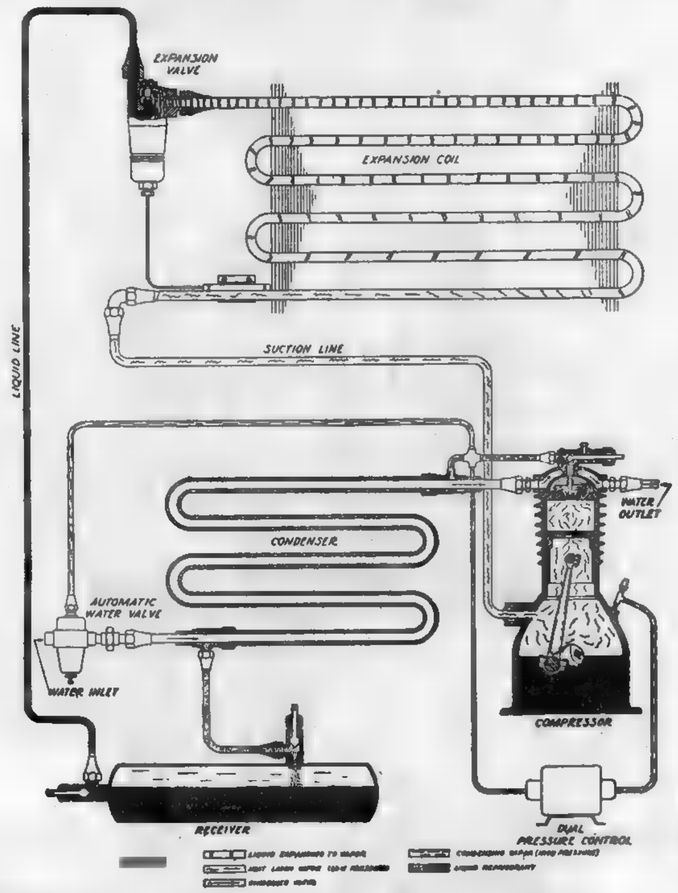


Fig. 218. A typical commercial water-cooled unit showing a tube-within-a-tube condenser and a water-cooled compressor
(Courtesy of: Universal Cooler Corporation)

moving parts are a little more than those allowed in the domestic mechanisms, but they still are one thousandth of an inch (.001) or less. Figure 218. The cylinder heads of these compressors must be cooled; radiating fins are there-

fore constructed into the cylinder head and cylinder body in the smaller sizes. However, refrigerant-cooled and water-cooled heads are the rule in the larger models. The speed of these compressors is kept to a minimum. Since the belief is that slow speed enables a longer-lived and a more efficient compressor, the usual speed varies between 300 and 500 revolutions per minute. The means for driving these compressors is almost universally the V-type belt in multiple. One finds two to ten belts quite common as the power transmitting medium.

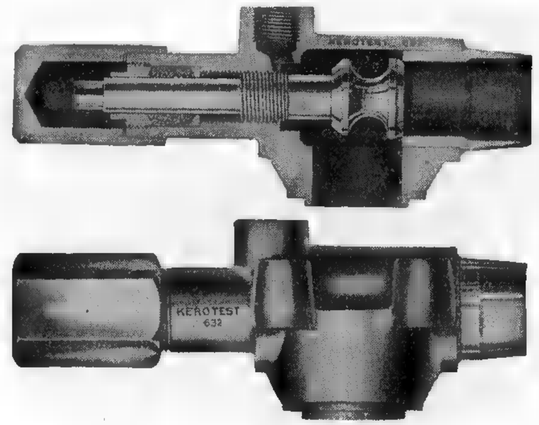


Fig. 219. A commercial system service valve
(Courtesy of: Kerotest Mfg. Company)

The service valves in the smaller units are exactly the same as those described for the domestic conventional designs. In one-ton machines and larger, especially those using stream-line fittings, a different standard has been developed. On the larger mediums the valves are still of the two-way type, but instead of the typical two-bolt flange, these valves are often attached by means of four bolts and are gasketed with recessed lead gaskets. Figure 219.

The very largest units have these valves furnished with hand wheels, whereas the others use a 3/8-inch square steel

stem. Many companies are now producing compressors with oil level sight gauges in them because of the importance to the life of the compressor in having this oil level correct.

284. THE AIR-COOLED CONDENSER:

Air-cooled condensers are quite common in the smaller units,

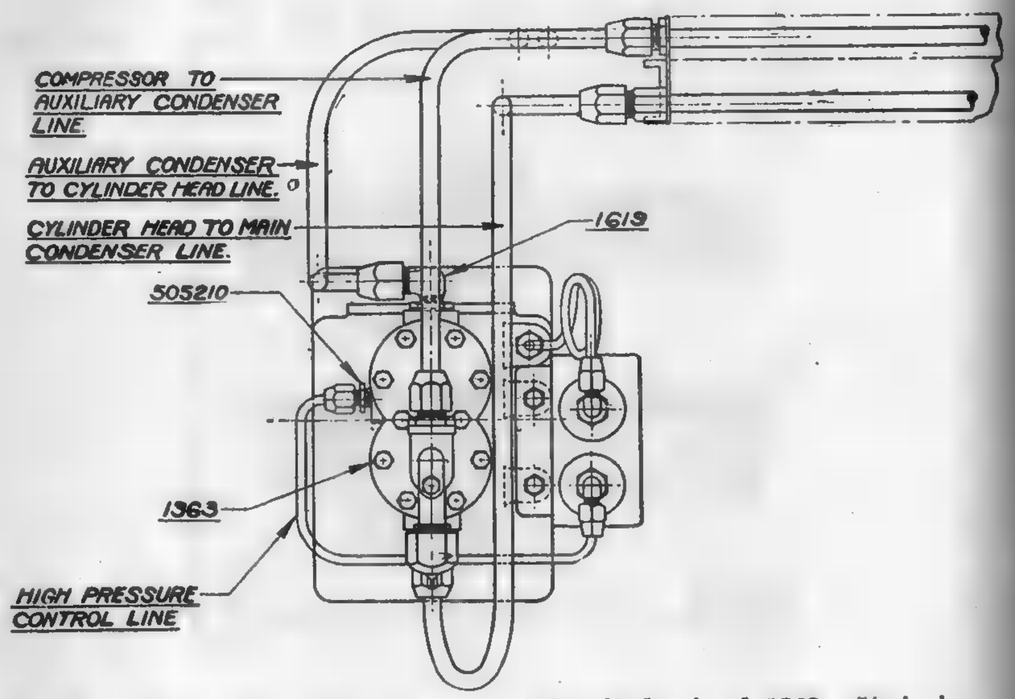


Fig. 220. A Kelvinator refrigerant-cooled cylinder head 1363. 5/16-inch cap screw; 1619. Refrigerant into cylinder head; 505210. Control line connection to cylinder head

(Courtesy of: Kelvinator Sales Corporation)

or where cooling water is not available. These are cooled by a large fan located on the motor or built into the compressor flywheel. The efficiency of the air-cooled condenser is increased by the use of a metal shroud around it and the cooling fan; in this case the air is usually drawn through the condenser rather than driven through it. These condensers have dip soldered fins and a double or triple layer of tubes is very frequently used. In the larger air-cooled units in order to cool the compressor head and valves, a double air-cooled condenser is sometimes used. This is so arranged that the refrigerant, when leaving the compressor, passes through one condenser and is then led back through jackets surrounding the cylinder head. From there it goes into the second condenser where it is finally cooled and condenses into a liquid. The partially cooled refrigerant, as it passes through the compressor head, keeps the compressor head cool. Figure 220.

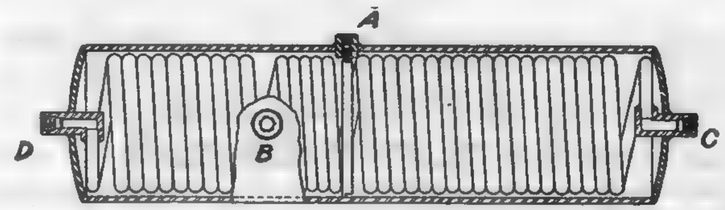


Fig. 221. A water-cooled condenser which also serves as the liquid receiver A. Refrigerant out; B. Refrigerant in; C. Water in; D. Water out

(Courtesy of: Williams Oil-O-Matic Heating Corporation)

285. WATER-COOLED CONDENSER:

The most common of the condensers used for cooling commercial refrigerating apparatus is the water-cooled type. This condenser is built in two different styles. The older style was constructed so that the refrigerant went directly from the compressor into the interior of the liquid receiver. Water circulated through copper coils built into the liquid receiver (usually 3/8-inch O.D. tubing). These coils cool and liquefy the refrigerant. Figure 221. The advantage of this style of construction is compactness of design, the elimination of fans and of a separate condenser. Also it enabled a very flexible type of assembly. Some companies produced

this type of condenser with the exception that instead of a coil of copper tubing being used as the water passages, the liquid receiver was made with a double wall; the cooling water circulated between the double walls of the liquid receiver.

286. TUBE WITHIN A TUBE CONDENSER:

A newer type of water-cooling condenser, and one becoming very popular because it is very flexible to the size of unit to

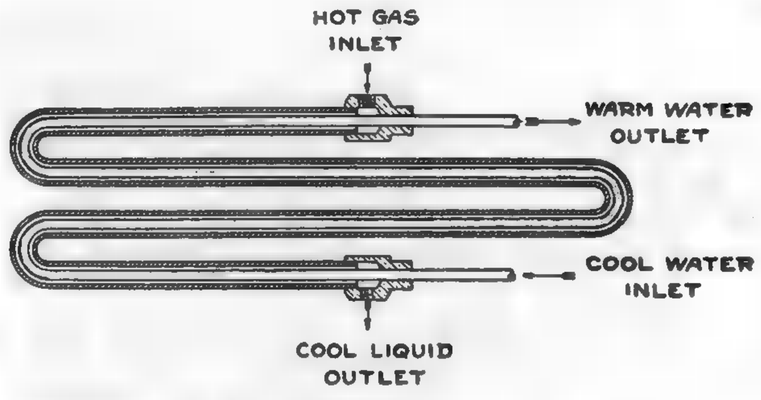


Fig. 222. A tube-within-a-tube water-cooled condenser
(Courtesy of: General Refrigeration Sales Company)

be cooled, is the double tube type. One tube is put within another in such a way that water passing through the inside tube cools the refrigerant in the outside tubing. The outside tubing is also cooled by the air in the room, enabling a very efficient construction. This condenser is either constructed in the cylindrical spiral style or in the rectangular style. The water enters the condenser at the point where the refrigerant leaves the condenser to go into the liquid receiver, and the water leaves the condenser at the point where the compressor

is connected to it. This is called the counter-flow construction. The warmest water is adjacent to the warmest refrigerant, and the coolest water adjacent to the coolest refrigerant. Figure 222. Water-cooled compressors are usually used with water-cooled condensers. The water flow, with few exceptions, is through the condenser first, then through the cylinder head, and finally out into the drain. The water flow through these condensers is regulated by means of an automatic water valve. Paragraph 308.

287. LIQUID RECEIVER:

The liquid receiver is a steel tank of welded construction and is usually equipped with two servicing valves; one is the typical liquid receiver service valve mounted between the liquid receiver and the liquid line, the other is a second liquid receiver service valve which is installed between the liquid receiver and the condenser. These two valves enable one to disconnect the liquid receiver or the condenser from the system separately. These cylinders are usually of cylindrical form mounted either in a vertical or horizontal position. The horizontal style is usually suspended underneath the compressor and motor frame. Some companies are now providing these liquid receivers with a device whereby the level of the liquid refrigerant may be very easily determined. In the construction involving a water coil inside the liquid receiver the shell is similar to the one just explained, but it is usually quite large for the same size compressor unit. The connections where the water-cooling coil enters the tank are either brazed or soldered. Brazing is preferred because of its greater mechanical strength.

288. COMMERCIAL COOLING UNITS:

Because of the great variety of demands in commercial refrigeration, special cooling unit designs are required for

many installations. These cooling units vary from coils of tubing immersed in a sweet water bath to forced insulation cooling units which have the air driven over the coils by means of an electric fan.

Cooling coils may be divided into two main divisions:

1. Those that are used for cooling air which in turn cools the contents of the cabinet.
2. The other type is submerged in a liquid such as brine or a beverage which is to be consumed.

Coils for cooling air are of two types. The most popular for most applications is the natural air convection coil. In this type the air circulation depends only on gravitational circulation. However, in air-conditioning and in some other installations, forced circulation air-cooling coils are becoming the only ones used. The three different classes of natural convection, air cooling coils are:

1. The frosting type of coil
2. The defrosting type of coil
3. The non-frosting type of coil

It is the condition under which a coil operates that determines under which of the above classifications a particular coil falls. The governing conditions are the desired temperature range of the cabinet and the temperature difference between the coil and the cabinet. Any particular coil may be operated under any of the above conditions, i.e., frosting, defrosting, or non-frosting.

289. FROSTING TYPE COOLING COIL:

The frosting type of coil was the first one produced by the refrigerating companies for use in cabinets of all kinds. These coils are of the low side float control type and consist of a very small amount of fin area held at a very low temperature. These coils never become warm enough (over

32°F.) to allow the frost accumulation to melt. These units are constructed of coils of seamless copper tubing brought out of the low side float chamber and run back into the same chamber. To these coils are soldered large copper fins. Figure 223. These coils were usually all soft soldered, but present practice is to silver solder the connections. The fins are of quite thin copper sheet (.015-inch to .025-inch) rein-

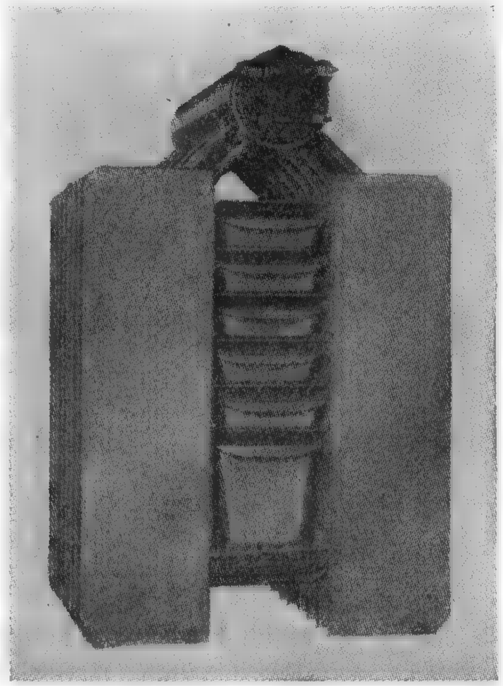


Fig. 223. A frosting type cooling coil using a low side float control
(Courtesy of: Kelvinator Sales Corporation)

forced around the edges and aligned with thin strips of metal. These cooling coils are usually tinned, or in some other way are made non-rusting. These coils have to be manually defrosted, inasmuch as the gradual accumulation of ice on the fins of the coil decreases the heat removing capacity of the coil tremendously. The frost which forms on the coils comes

from the moisture in the air which freezes on them. This withdrawal of moisture from the air leaves it dry, and the dry air in turn dries out the food in the cabinet rapidly.

290. DEFROSTING COOLING COIL:

To eliminate the difficulties encountered in defrosting the frosting type coils, companies have produced a coil which may be classified as the defrosting type. This coil may be

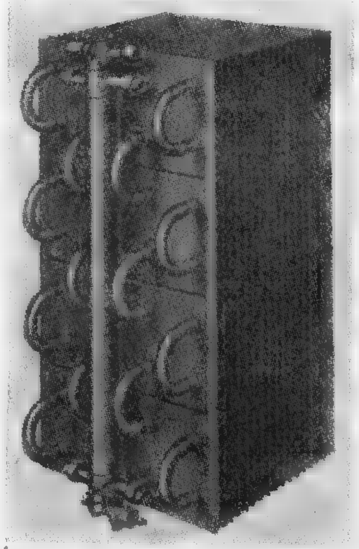


Fig. 224. A defrosting type cooling coil using a thermostatic expansion valve
(Courtesy of: Kelvinator Sales Corporation)

used with the low side float or with the thermostatic expansion valve refrigerant control. The area of the coil is increased so that it will behave as follows: during the running of the compressor this coil will stay at a temperature of 20°F. to 22°F. This will cause a frost accumulation on the coil, but after the compressor stops this coil becomes so warm that all the frost is supposed to melt from the coil before the compressor starts again. Figure 224. This arrangement works in some installations, but in others it is somewhat unsatisfactory. It appears that during the off part of the cycle the top of the coil will defrost and its moisture will run down the fins, but before the moisture has time to escape it often freezes around the lower parts of the fins. This ice accumulation on the bottom fins will block the air circulation around the coils and interfere with refrigeration.

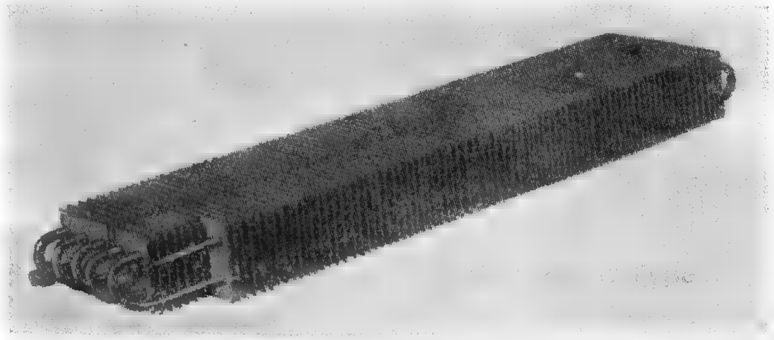


Fig. 225. A non-frosting type cooling coil using a thermostatic expansion valve. Note the use of a flange in place of the flared connection
(Courtesy of: Kelvinator Sales Corporation)

291. NON-FROSTING COIL:

Because of the troubles experienced with frosting coils some companies are producing patented non-frosting coils. These coils use only the thermostatic expansion valve type of refrigerant control. The construction is that the area of the coils is so great that in order to cool the box down to 36°F. to 38°F. these coils need never become colder than 31°F. to 32°F. which naturally allows them to be named non-frosting. Occasionally these coils accumulate a very slight coat of frost just before the compressor shuts off. Figure 225. This frost disappears, however, immediately after the compressor

stops. The big advantage of this type of coil is the fact that since it is so warm itself it does not have a tendency to draw the moisture out of the air very rapidly; therefore it is possible to maintain a 75 per cent to 85 per cent relative humidity in the cabinet, which is the amount required to keep the produce fresh and to keep it from losing weight. Non-frosting coils are slightly more bulky than the frosty types. These coils should be baffled to direct the flow of air around them. The baffling should be so constructed that the air will flow continually in one direction past the coil. Paragraph 335. Baffling tends to speed up the cooling of the air and makes the coil more efficient, but it does occupy some space.

292. FORCED CIRCULATION COOLING COIL:

Forced circulation cooling coils consist of a compact arrangement of refrigerant cooled tubes and fins about which air is blown by means of an electric fan. Both the coil and the fan are usually enclosed in a metal housing. These coils have the advantage of taking up a very small amount of room and do not need any baffling. They do, however, have a tendency toward rapid dehydration of foods unless special care is taken. If the coil is large and operates at a low temperature difference (5°F. to 10°F.) and the air is circulated slowly, there is less tendency to dehydrate foods. In installations in which dehydration is not important, small coils may be used operating at a high temperature difference (20°F. to 30°F.), and the air may be blown rapidly through the coil. Thermostatic expansion valve refrigerant controls are usually used with forced convection coils. The motor which drives the fan may be from 1/75 H.P. up, and may run continuously or may be controlled by the coil or the box temperature. The refrigerant temperature is usually held quite low, but the coil does not frost because of the rapid air circulation. Figure 226. However, considerable sweating does occur and facilities for drainage must be incorporated in the installation. A coil of this kind is noted for the rapidity with which it will cool a refrigerator cabinet. One can almost neglect the heat leakage in calculating the "pull down" time

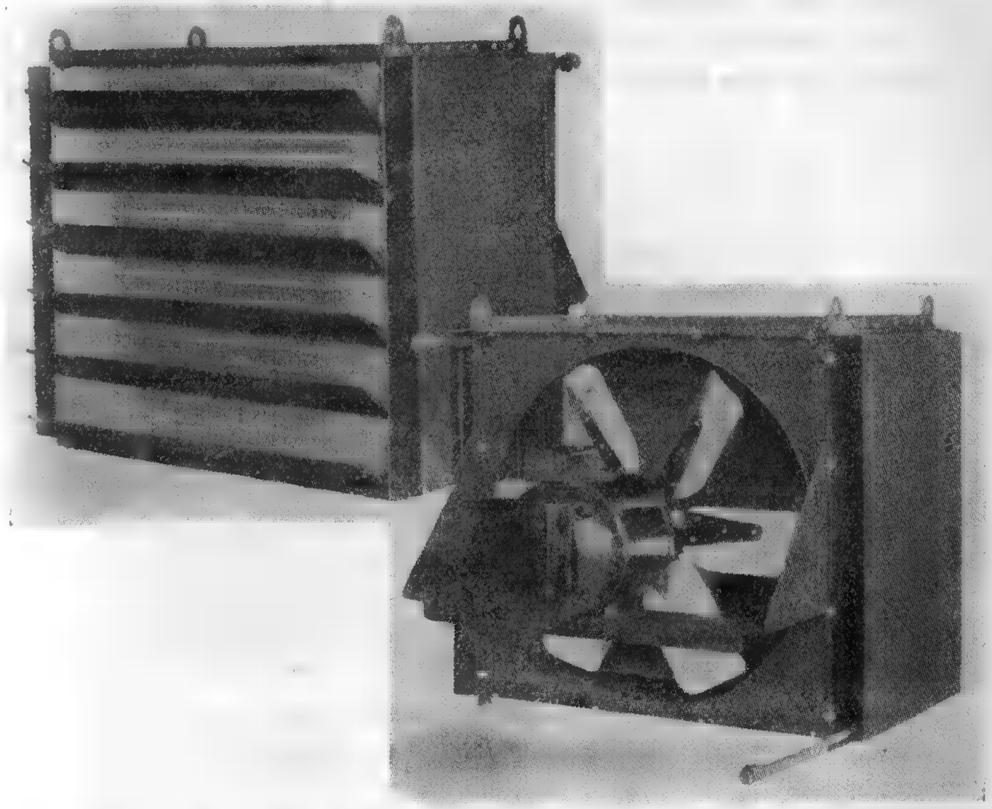


Fig. 226. A forced-circulation type cooling coil
(Courtesy of: McCord Radiator & Mfg. Co.)

for this type of coil. In storage cabinets used for bottle beer, for foods in sealed containers, and for air-conditioning work this forced convection cooling coil is becoming very popular.

293. IMMERSED COOLING COIL (BRINE):

The other big field of commercial cooling coils is the immersed type, such as an ice cream cabinet wherein the ice cream containers are surrounded by calcium chloride or alcohol brine; a small, plain, tube-cooling coil submerged in this brine keeps the cabinet at 0°F. to 10°F. Figure 227. The efficiency of these coils is greatly increased because of the fact that liquids transfer heat to metals much faster than

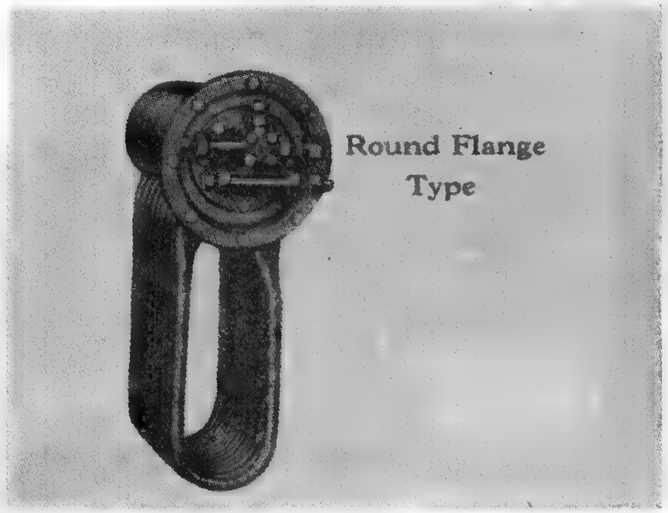


Fig. 227. Immersed cooling coil
(Courtesy of: Kelvinator Sales Corporation)

air by a ratio of 5 or 6 to 1. That is, a submerged coil can remove 15 to 20 B.T.U. per hour, per degree temperature difference, per square foot of coil surface, whereas air-cooling coils can remove only 2 to 4 B.T.U. under the same conditions. These coils may use either a low side float or a thermostatic expansion valve refrigerant control when used in multiple installations.

294. IMMERSED COOLING COIL (SWEET WATER):

Another type of submerged cooling coil is a coil submerged in ordinary tap water which is termed a sweet water bath. The common example of this type is the water-cooling device used in soda fountains. The cooling coil is submerged in the sweet water, and another coil in which the water is to be cooled and consumed by the customer is submerged in this same water. It is the feature of this design to allow this

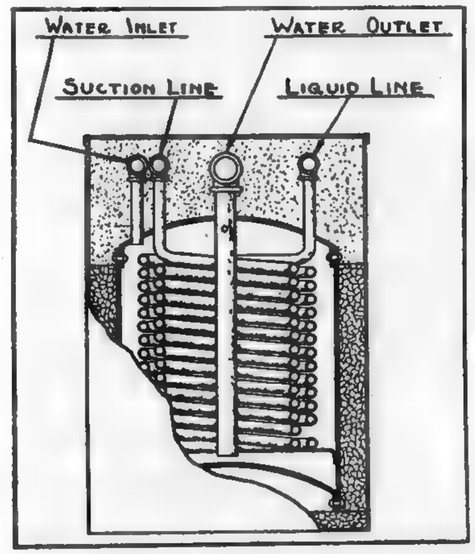


Fig. 228. Refrigerant tube immersed in the beverage type of cooler
(Courtesy of: Filtrine Mfg. Company)

sweet water to freeze a little around the coil during what is called the non-load period. This light ice accumulation around the cooling coil will act as a storage reserve of refrigeration. Sulphur dioxide systems use a low side float for this work, while methyl chloride and Freon systems use the thermostatic expansion valve. Figure 213. In the event a thermostatic expansion valve refrigerant control is used the thermostatic bulb should be clamped to the outlet of the coil.

The coil should reach to the bottom of the bath if the temperature of the bath is to be less than 39.1°F. Water between 39.1°F. and 32°F. tends to expand and rise. Therefore, the coldest water, between these temperatures, will be at the top.

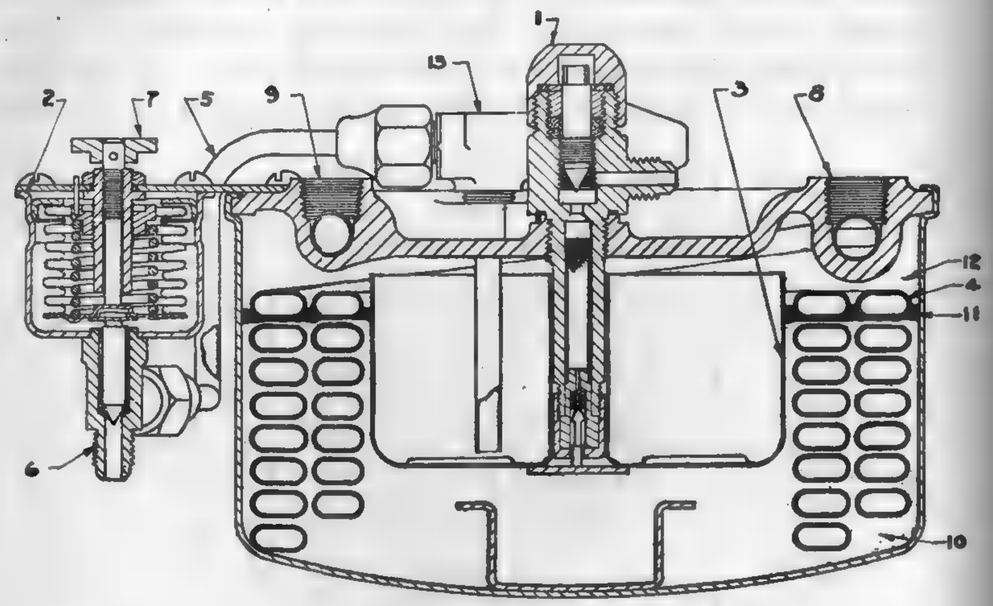


Fig. 229. The Temprite beverage cooler
1. Float valve with manual shut-off valve; 2. Temperature control valve; 3. Float; 4. Water cooling coil; 5. Suction tube; 6. Suction outlet to compressor; 7. Temperature control adjusting screw; 8. Cold water outlet; 9. Tap water inlet; 10. Liquid refrigerant; 11. Oil strata; 12. Refrigerant vapor; 13. Manual suction shut-off valve
(Courtesy of: Temprite Cooler Corporation)

295. PRESSURE TYPE BEVERAGE COOLER:

A type of cooling coil which may be classed as the submerged type is the pressure type beverage cooler. In this cooling coil the liquid refrigerant is carried in a tube submerged in the beverage to be cooled. Its construction is similar to that of the liquid receiver type of water-cooled condenser. This construction is quite common for instantaneous water coolers.

Figure 228. A precaution to be observed in this type is that the temperature of the beverage should never be such that it will freeze to any extent. Another type of submerged cooling coil design is illustrated in the beverage cooler made

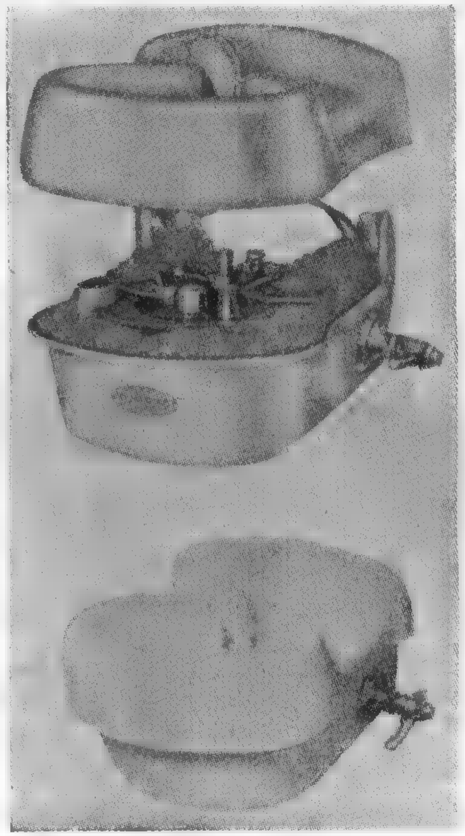


Fig. 230. A Temprite drinking fountain and cooler
(Courtesy of: Temprite Cooler Corporation)

by the Temprite Cooler Corporation. This consists of a coil of tubing, carrying the beverage to be consumed, submerged in a quantity of liquid refrigerant. The liquid refrigerant is controlled by a low side open pan type float. Figures 229 and 230.

296. REFRIGERANT CONTROLS:

For single installations involving one cooling unit and one condensing unit the four types of refrigerant controls used are: expansion valves, high side floats, low side floats and capillary tubes. These are explained in Chapters II and VII. As previously mentioned, in multiple installations which cover a greater magnitude of uses, the only two types of refrigerant controls usable are the low side float and the thermostatic expansion valve. The trend is toward thermostatic expansion valves, but there are many multiple low side float systems still in use.

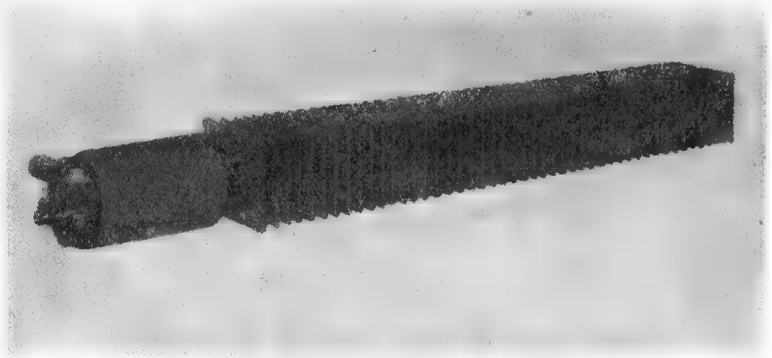


Fig. 231. A low side float finned cooling coil
(Courtesy of: Kelvinator Sales Corporation)

297. THE LOW SIDE FLOAT:

The low side float was the first refrigerant control to be used in multiple installations. These are very satisfactory controls when used with sulphur dioxide, principally because the sulphur dioxide low side float coils do not easily become oil bound. Figure 231. Methyl chloride may also be used in multiple low side float systems. Some examples of methyl chloride installations are the Absopure and Peerless types. Methyl chloride, however, is lighter in the liquid form than oil; upon being admitted into the low side float chamber, the

methyl chloride tends to stay on top of the oil. This often results in a complete oil binding of the unit unless special precautions are taken to avoid it. The low side float controls are usually of the sealed ball type float operating a needle through a simple lever mechanism. The needles are constructed of a good grade of steel, stainless steel, or Stellite. The seats of these valves are usually made of a softer metal than the needle, and the materials range from brass or Monel metal to stainless steel. The float mechanism is usually removable, the head being bolted into the float chamber by means of six to eight cap screws. The headers are equipped with shut-off valves, one being located between the liquid line and the header and the other being located between the suction line and the header. Most of these valves are attached to the header by means of a paper-gasketed flanged-fitting held in place by two 5/16-inch cap screws. One exception is the Frigidaire construction which uses a suction line valve held in place by four ¼-inch cap screws, and uses a lead gasket seal, whereas the liquid line valve is threaded into the headers, using a ⅜-inch pipe thread. The usual Frigidaire construction has a screen located between the liquid line and the liquid line valve, and in the older models another screen between the liquid line valve and the header. In those types of headers which have a bolted liquid line valve, the screen is placed between the valve and the header. The servicing valves located on the header should be sealed with a cap which covers the valve stem to prevent corrosion. Lead gaskets are used to seal the joint between the header and the body of the cooling coil because it is non-corrosive, moisture proof, and easy to remove.

298. THE THERMOSTATIC EXPANSION VALVE:

Thermostatic expansion valves, which were developed in the

late twenties are rapidly becoming the leading multiple refrigerant control. This control was originally produced to eliminate trouble with oil binding that was experienced with low side float installations. This type of refrigerant control usually requires less refrigerant than the low side float system.

The theory of the thermostatic expansion valve is as follows: a power element, capillary tube, and thermostatic bulb apparatus is mounted into a typical expansion valve and causes the valve to keep the coil filled with refrigerant rather than to maintain a definite low side pressure. Figure 232. The thermal expansion valve under any circumstances does

Fig. 232. A thermostatic element used in thermostatic expansion valves
(Courtesy of: Fedders Mfg. Company)

not attempt to regulate the low side pressure, but rather controls the filling of the cooling coil with refrigerant and the compressor establishes its own pressure upon this refrigerant. Figure 233. This control was first used for the methyl chloride systems, but its inherent advantages soon led to its adoption for all multiple installations. It has one distinct advantage over the low side float multiple system in that several different temperatures may be obtained without using any other special device. This may be accomplished by starving the coils in the cabinets desired to be kept at a warmer temperature.

The construction of this valve consists of a brass body into which the liquid line and cooling unit connections are built. In this body is located the needle and seat, the former

of which is joined to a flexible metal bellows. This bellows, in turn is actuated by a non-heat conducting rod connected at the other end to a sealed bellows (power element), which is joined to the thermostatic bulb by means of a 1/8-inch capillary tube; all are carefully sealed. This thermostatic

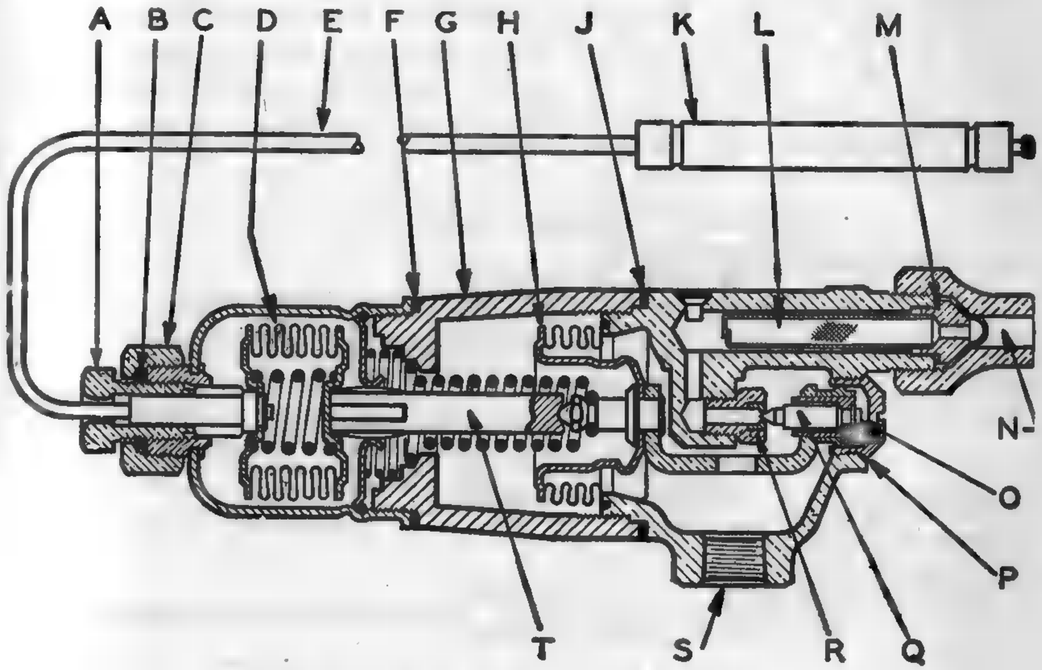


Fig. 233. A thermostatic type expansion valve
A. Adjusting nut; B. Adjusting nut body; C. Lock nut; D. Power element; E. Capillary tube; F. Seal; G. Body; H. Sealing bellows; J. Seal; K. Thermostatic bulb; L. Screen; M. Plug; N. Refrigerant inlet; O. Plug; P. Seal; Q. Needle; R. Seat; S. Refrigerant outlet; T. Arm
(Courtesy of: Detroit Lubricator Company)

element must be charged with the same refrigerant that is used in the system. Each manufacturer has a code for identifying the refrigerant with which the thermostatic element is charged. Some use letters such as S, M, etc., indicating sulphur dioxide or methyl chloride. Others use colors or

numbers to denote the charge. The whole valve is sealed up to prevent moisture seeping into any part. A screen or strainer is always located between the liquid line connection and the orifice to keep dirt away from the needle and seat of the valve. Some air-conditioning systems use as many as six of these thermostatic expansion valves on one cooling coil.

The proper installation of the thermostatic expansion valve is the first factor to obtain satisfactory usage. The operation of the valve is simple. The bulb of the thermostatic expansion valve should be located at the outlet of the cooling

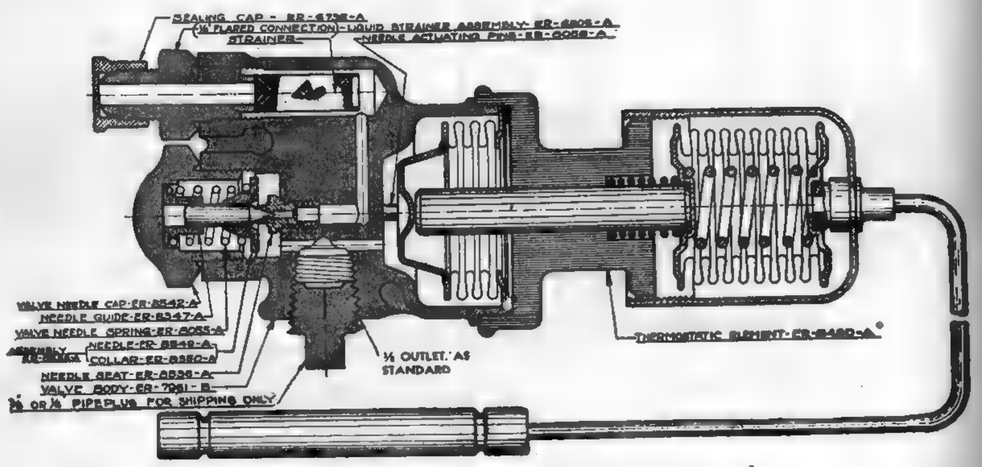


Fig. 234. A thermostatic type expansion valve
(Courtesy of: Fedders Mfg. Company)

coil. The bulb when warm vaporizes the refrigerant in it and builds up a pressure in the power element by means of the capillary tube connection, and the bellows expands. This expansion forces the needle open, admitting liquid refrigerant into the cooling coil. Figure 234. This continues until the whole coil is cooled and the suction line starts to cool. As soon as the suction line, to which the power bulb is attached, becomes cooled sufficiently, the pressure in this bulb decreases, due to condensation of its refrigerant, which relieves

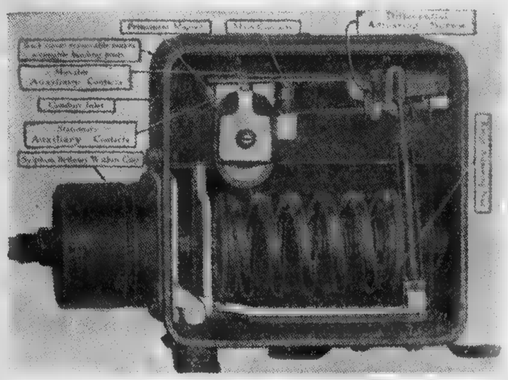
the pressure in the bellows. This causes a contraction of the bellows and the expansion valve is shut off, leaving the cooling coil filled with liquid refrigerant vapor. The refrigerating mechanism now lowers or decreases the low side pressure, for it continues to run until the pressure motor control cuts out, giving the temperature desired. When the condensing unit stops, the thermostatic expansion valve closes. This closing is accomplished by the building up of the low side pressure the instant the condensing unit stops. This is important, otherwise the cooling coil would become flooded with refrigerant. The needles are usually made of Stellite or stainless steel while the seats are made of stainless steel or Monel metal. Most of these valves are equipped with an adjustment. The adjustment is designed to move the power element against the expansion valve bellows if it is turned in. This opens the needle and tends to admit more refrigerant into the cooling coil. If the adjustment is turned out or contra-clockwise the power element will be moved away from the expansion valve bellows. This action will "starve" the cooling coil or will result in closing the needle before the coil becomes full of liquid refrigerant. See Paragraph 447 for a technical discussion of the thermostatic expansion valve operation.

299. MOTOR CONTROLS:

The two types of motor controls used in commercial refrigeration are identical to those used in domestic refrigeration, namely, the pressure motor control, and the thermostatic motor control. In multiple commercial work, pressure motor controls are the most popular. The reason for this is that the low side pressure is an indication of the temperature in the coil, and therefore one control works well regardless of

the number of coils connected to it. Figure 235. These controls provide both range and differential adjustments; explanation of the various range and differential adjustments will be found in Paragraphs 93 to 101.

The controls consist of a switch built into a toggle arrangement which is acted upon by a bellows whose pressure may be either temperature, or pressure operated. As the pressure in the bellows builds up, the toggle is snapped and the switch contact points close, starting the motor. As the



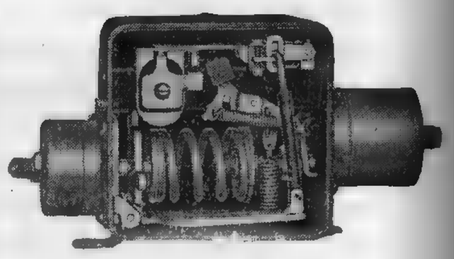


Fig. 235A. A low side pressure commercial motor control
(Courtesy of: Penn Electric Switch Company)

Fig. 235B. The same low side pressure motor control as in Figure 235A with an auxiliary high pressure cut-out
(Courtesy of: Penn Electric Switch Company)

compressor runs, it reduces the temperature, or the pressure on the bellows, until the toggle is snapped the other way, opening the switch and stopping the motor. These controls have a range adjustment which is usually an adjustable spring pressing against the bellows. When the spring pressure against the bellows is increased, the cut-in and cut-out points are raised equally. The range adjustment controls the box temperatures desired. The distance between the cut-in and cut-out points registered either in degrees F. or in pounds per square inch is called the differential. It is an adjustment which controls the amount or the distance the toggle snaps. The three types of differential adjustments are:

1. Adjusting cut-out only.
2. Adjusting cut-in only.
3. Adjusting both (either putting them farther apart or closer together).

See Paragraph 538 for new material on commercial controls.

300. PRESSURE MOTOR CONTROL:

This control is usually located on the condensing unit, and the low side pressure in the compressor crank case operates the mechanism. Some companies recommend tapping into the low side suction line about 10 to 15 feet from the compressor for this control. These motor controls are hooked directly into the line for motors up to 1 H.P.-A.C., ½ H.P.-D.C., and ½ H.P. polyphase. If the size of the motor is greater than this, an electric starting device is used in conjunction with the control. This device is a starting relay of the magnetic type. The range settings vary with the application. The cut-out pressure should correspond to a temperature approximately 10°F. below the desired coil temperature, while the cut-in pressure should correspond approximately to the coil temperature. The differential setting will vary depending upon the temperature accuracy desired. A wide pressure difference will allow some variation in cabinet temperature and will lengthen the cycle interval of operation of the condensing unit. A differential set to close limits will maintain a more uniform cabinet temperature and will shorten the cycling interval of the condensing unit. A pressure difference between the cut-in and cut-out point commonly used is 10 pounds per square inch for sulphur dioxide, 15 pounds per square inch for methyl chloride. and 20 pounds per square inch for Freon.

Consider 2 inches of mercury vacuum equal to 1 pound per square inch.

301. THERMOSTATIC MOTOR CONTROL:

The thermostatic motor control is similar to the pressure

Fig. 236. A temperature motor control using a high pressure safety cut-out. Note the range adjusting screw on the right hand side of the case
(Courtesy of: Detroit Lubricator Company)

control in construction and arrangement except for the power bulb and capillary tube. This control is usually used only in large sized single installations. However, satisfactory set-ups have been made in multiple installations which assume

that, when the one controlled cabinet has cooled sufficiently, the others have also. Figure 236.

The thermostatic motor controls are popular in brine cooling installations with the power element submerged in the brine. Ice cream cabinets are a typical example. When used in single cabinet installations the power element is usually mounted in the box 4 feet up from the floor between the cold and warm air flues and at least 2 inches from the wall. A recent innovation in multiple installations involving an ice cream cabinet is that a pressure motor control, located on the condensing unit, and a thermostatic motor control, located on the ice cream cabinet, are connected in parallel to make the condensing unit operate until both the ice cream cabinet temperature and the low side pressures are low enough. It is only when both controls are open that the unit will stop.

An important difference between commercial and domestic controls is the fact that commercial controls have incorporated in them a safety device known as a high pressure safety cut-out. This device consists of a bellows built into the control and connected to the high pressure side of the system. It is frequently connected to the cylinder head to enable one easily to disconnect the control from the system. This bellows is attached to a plunger in such a manner that if the head pressure becomes too high due to air in the system, the condenser water being shut off, or other causes, this bellows will expand, push the plunger against the switch, and shut off the motor. This control is called a safety device because its action prevents the building up of dangerous pressures within the system; more important still is the fact that it prevents ruining the motor through over-loading and overheating. These controls are usually set to cut-out at about 125 pounds per square inch pressure, except in Freon sys-

tems, in which case the control is set at about 150 to 160 pounds per square inch. Figure 237.

302. TWO-TEMPERATURE VALVES (SUCTION LINE PRESSURE CONTROL):

In many multiple installations it is necessary to maintain

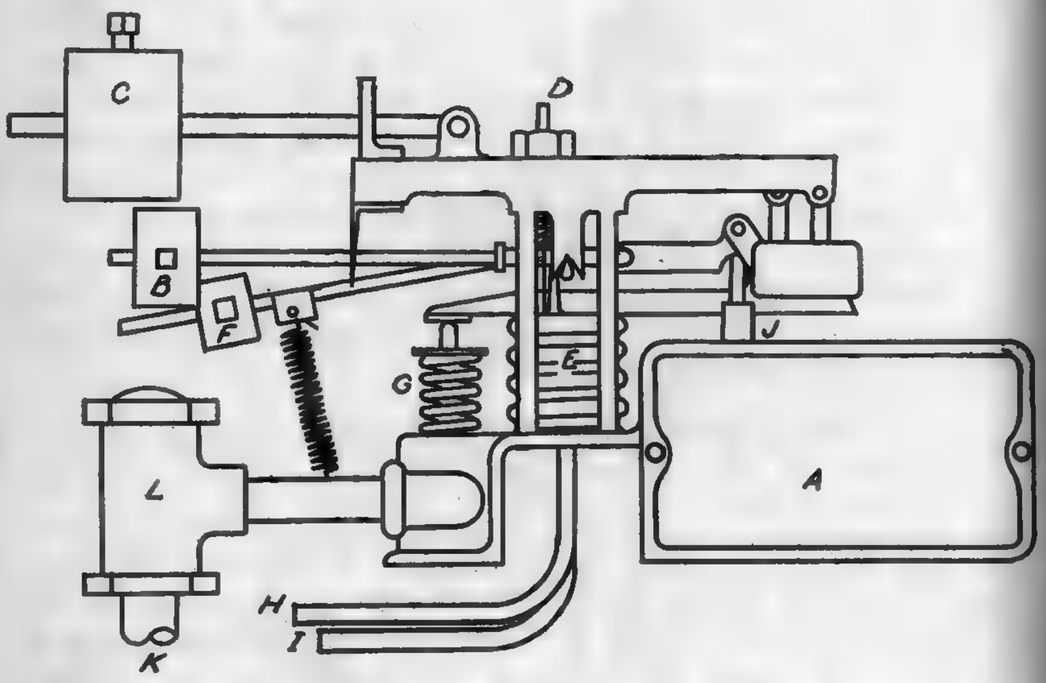


Fig. 237. A sliding weight, low pressure motor control, high pressure safety cut-out, and water valve combination
A. Switch box; B. Coarse range adjustment; C. Cut-in differential adjustment; D. Fine range adjustment; E. Low pressure bellows; F. Permits adjusting the high pressure cut-out and the water valve; G. Water valve; H. Low pressure tubing; I. High pressure tubing; J. Switch actuating rod; K. Water in; L. Water screen

different temperatures in the various coils. Thermostatic expansion valves may be used if the temperature differences are not too great (not over 5°F.); but in some instances, such as with a storage cabinet and an ice cream cabinet com-

bination, the temperature differences are too great to be taken care of in this manner. To provide for this a two-

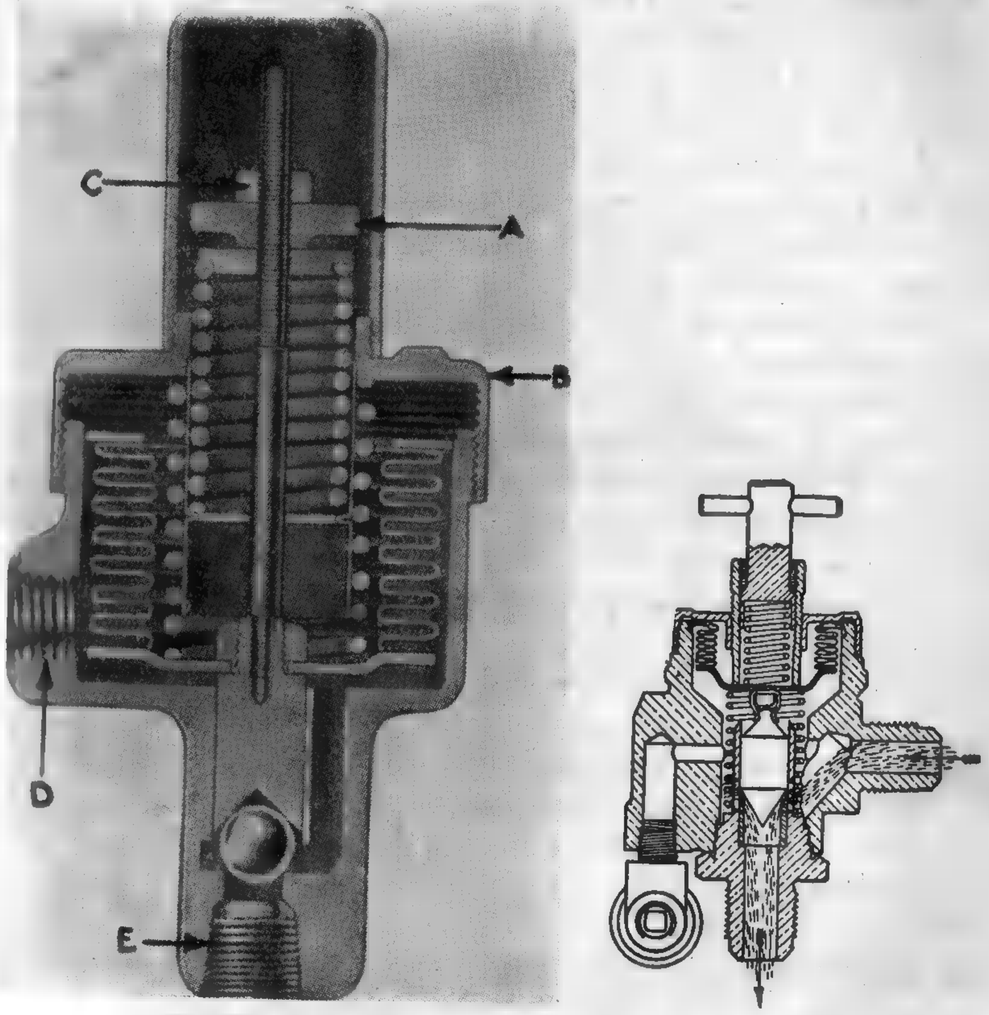


Fig. 238. A metering type, two-temperature valve
A. Fine adjustment; B. Coarse adjustment; C. Lock nut; D. Inlet; E. Outlet
(Courtesy of: Temprite Cooler Corporation)
Fig. 238A. A metering type, two-temperature valve
(Courtesy of: Fedders Mfg. Company)

temperature valve is put into the suction line; it operates in such a manner that it prevents the pressure of the warmest

coil from going below a predetermined setting. These valves are sometimes called constant pressure valves or pressure reducer valves. Their construction consists of a bellows, a needle, and seat arranged in such a way that the bellows is actuated by the pressure in the warmest coil. Figure 238. As the compressor pumps the low side down to this predetermined pressure, the bellows shuts off this valve, preventing the pressure in the warmest coils from going below the pressure desired. As the pressure in the coil builds up, due to the vaporizing of the refrigerant in the coil, the bellows again opens the valve allowing the gas to be drawn to the compressor.

Since the pressure maintained upon the surface of a quantity of liquid refrigerant determines the temperature at which the refrigerant will evaporate, this suction line valve will control the temperature of the coil to which the suction line is attached, even though the suction pressure of the compressor is considerably below the coil pressure. The controlled coil or coils such as explained above should not constitute more than 40 per cent of the total load of a system. If the controlled load would amount to more than 40 per cent separate condensing units should be used. There are three types of two temperature valves: first, the metering type; second, the snap action type; third, the temperature control type.

303. METERING TYPE, TWO-TEMPERATURE VALVE:

The metering type, two-temperature valve (the first one developed) acts more as a throttling device than as a shut-off valve. It opens and closes when the pressure varies only a fraction of a pound, having no differential. This control is very popular in an ice cream cabinet and a soda fountain installation. The needle may be better termed a plunger be-

cause the valve openings must be made large enough not to offer any restriction to the gas flow. Many of these metering controls have a very small adjustment range, being especially designed to maintain beverage temperature pressures. The parts are heavily cadmium plated because the valve is often located in damp places. It must not corrode. Figure 239.

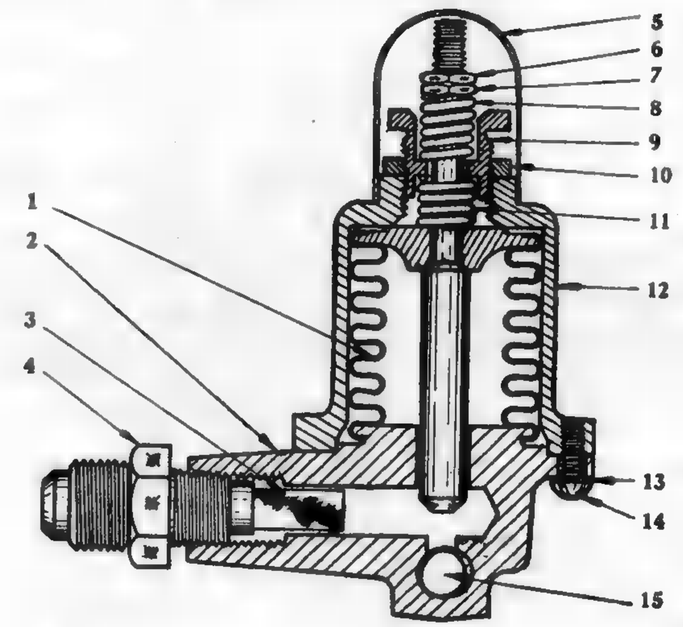


Fig. 239. A metering type, suction temperature valve
1. Bellows; 2. Body; 3. Strainer; 4. Controlled cooling unit connection; 5. Cap; 6. Lock nut; 7. Small adjusting nut; 8. Upper adjusting spring; 9. Large adjusting nut; 10. Lock nut; 11. Lower adjusting spring; 12. Bellows case; 13. Lock washer; 14. Screw; 15. Uncontrolled cooling unit connection
(Courtesy of: Kelvinator Sales Corporation)

304. SNAP-ACTION TYPE, TWO-TEMPERATURE VALVE:

The snap action type is such that, when the valve closes, a decided rise in pressure is made in the warm coil before the

valve will open again. Figure 240. The differential construction is the typical toggle arrangement which is in motor controls and permits both ■ range and a differential adjustment for the back pressures of the warmest coil. This con-

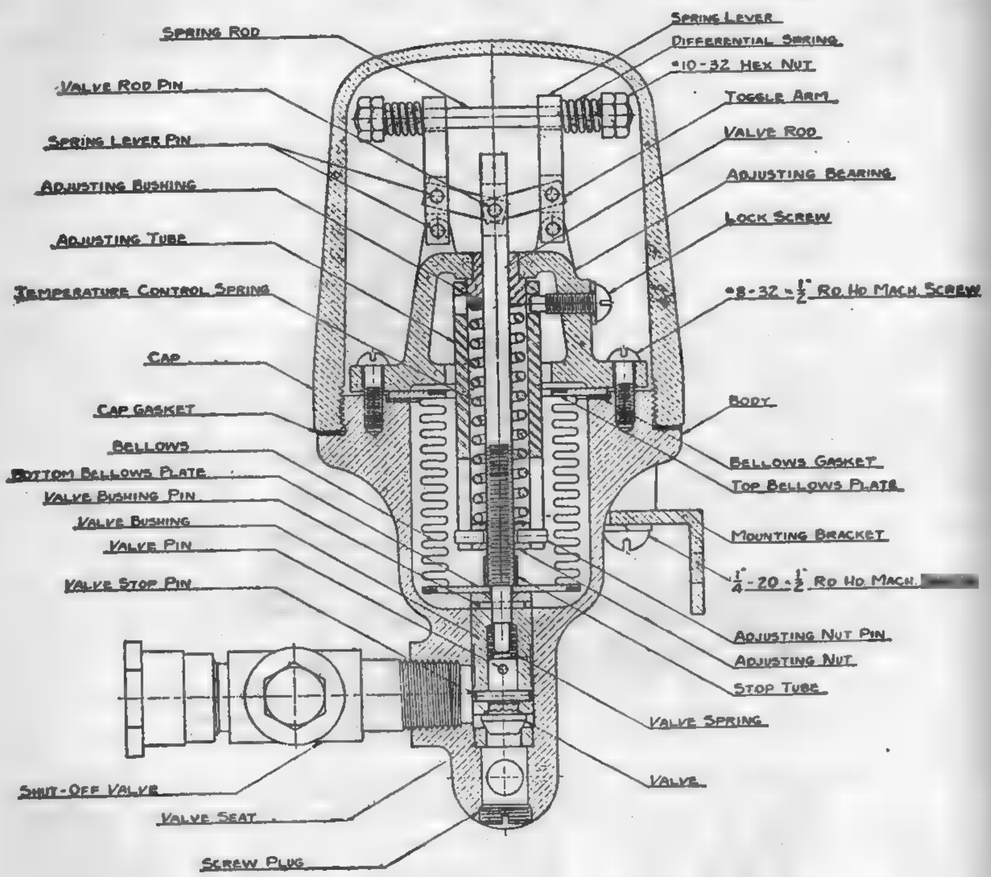


Fig. 240. A snap-action, two-temperature valve
(Courtesy of: Fedders Mfg. Company)

trol is used more with equal temperature coils, but with coils of unequal capacity, although it may be used in place of metering type valves. Such an installation would be illustrated by ■ multiple system cooling a walk-in cooler and a

display case. The two-temperature valve should be located on the suction line to the display case. Another type of

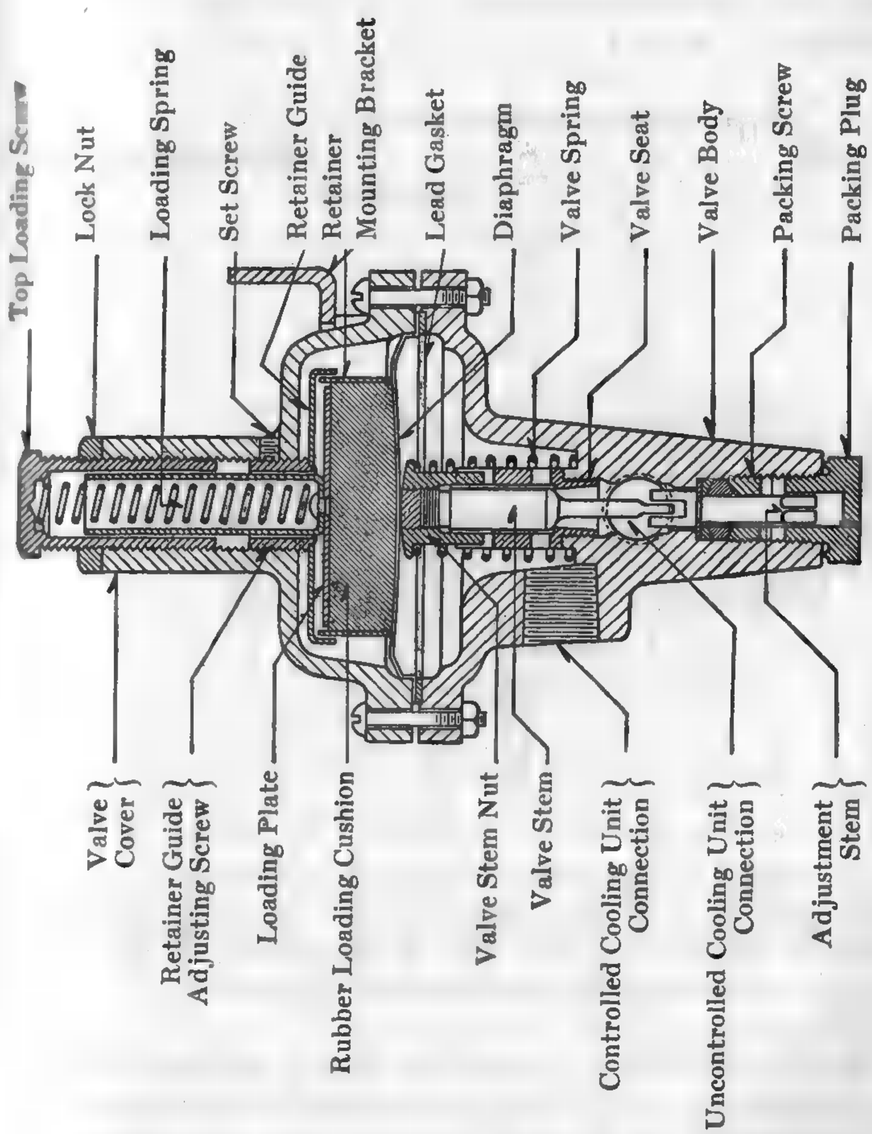


Fig. 241. A diaphragm type, two-temperature snap-action valve
(Courtesy of: Barostat Company)

snap-action, two-temperature valve is the Barostat which uses the principle of a snap-action diaphragm. Figure 241.

305. THERMOSTATIC TYPE, TWO-TEMPERATURE VALVE:

A recent type of two-temperature valve is a temperature control which is built very much like a thermostatic expansion

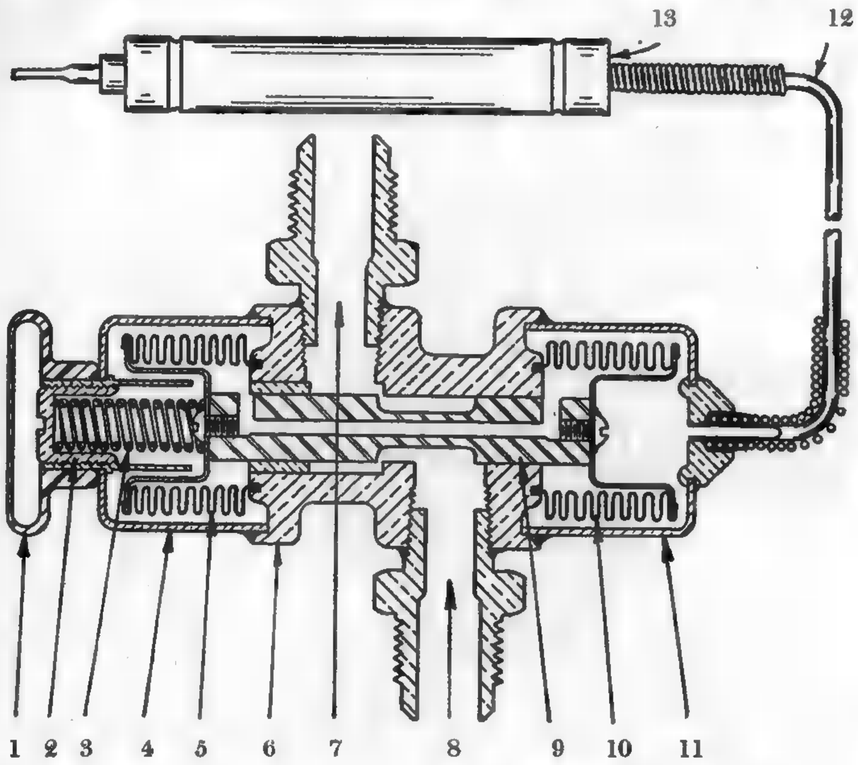


Fig. 242. A thermostatic type, two-temperature valve
1. Bellows case cap; 2. Adjusting screw; 3. Adjusting spring; 4. Bellows case; 5. Adjusting bellows; 6. Body; 7. Outlet or inlet; 8. Inlet or outlet; 9. Control rod; 10. Control bellows; 11. Bellows case; 12. Control line; 13. Control bulb
(Courtesy of: Kelvinator Sales Corporation)

valve. Its operation is similar in that it operates from the temperature of the coil. It has a capillary tube and a power bulb similar to the thermostatic expansion valve, along with a bellows arrangement to utilize the different pressures created in the power bulb. When the coil which this particular

two-temperature valve controls becomes cool enough, the power bulb in cooling off also lowers the pressure in the bellows, thus operating the valve plunger and shutting off the valve. Figure 242. This prevents the pressure from becoming any lower in the coil to which this valve is attached, thereby controlling the minimum temperatures of the coil. As the coil warms up, the power bulb also warms up and the increase in pressure is transmitted to the bellows. The valve is then opened permitting the compressor to draw vaporized refrigerant from that coil again. This latter type of valve is always located on the warmest coil as are the two previous types.

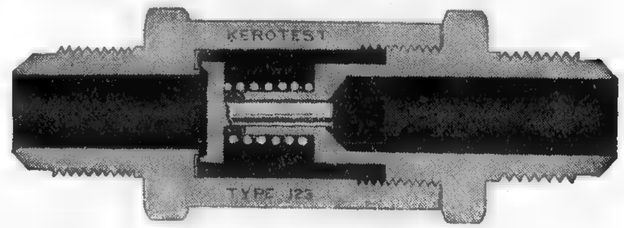


Fig. 243A. A suction line check valve used in multiple temperature installations
(Courtesy of: Kerotest Mfg. Company)

306. CHECK VALVES AND SURGE TANKS:

Many multiple installations are made in which one condensing unit is connected to several coils all of which are at different temperatures. Two temperature valves are used to procure these temperatures. Check valves are sometimes put in the suction line of the coldest coils to eliminate erratic refrigeration. After the condensing unit has stopped, one of the two-temperature valves may open before the condensing unit turns on, tending to flood the low side with a relatively warm refrigerant gas. This gas will also travel along the suction line of the coldest coil and if it enters this coil it will start condensing, releasing its latent heat. This will make the

cold coil defrost or at least warm up somewhat. The check valve installed in the suction line of the coldest coil will only allow gas to be drawn from this coil. Figure 243A.

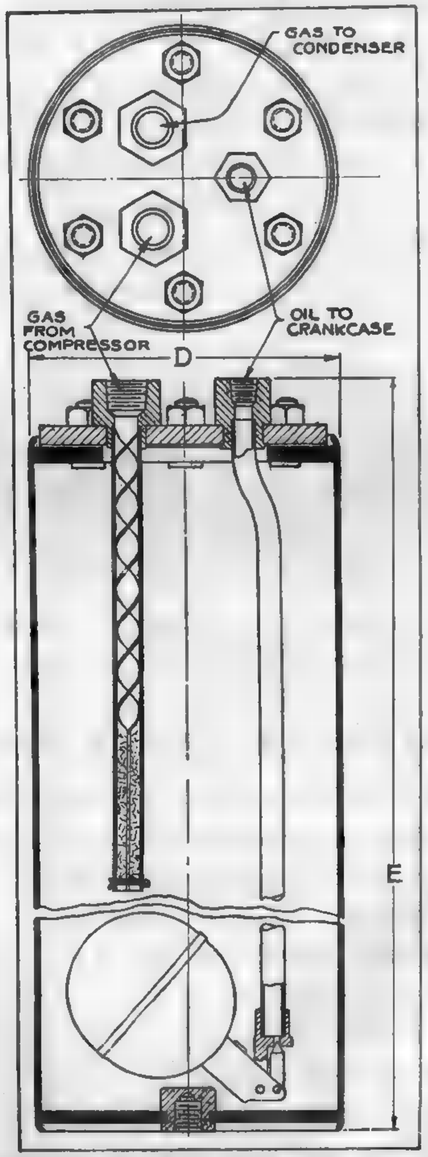


Fig. 243B. A typical oil separator
(Courtesy of: American Injector Company)

A multiple temperature installation has a tendency to short cycle a pressure controlled condensing unit due to the pressure fluctuations resulting from the opening and closing of the two-temperature valves. To eliminate this trouble a large cylinder or surge tank is installed in the main suction

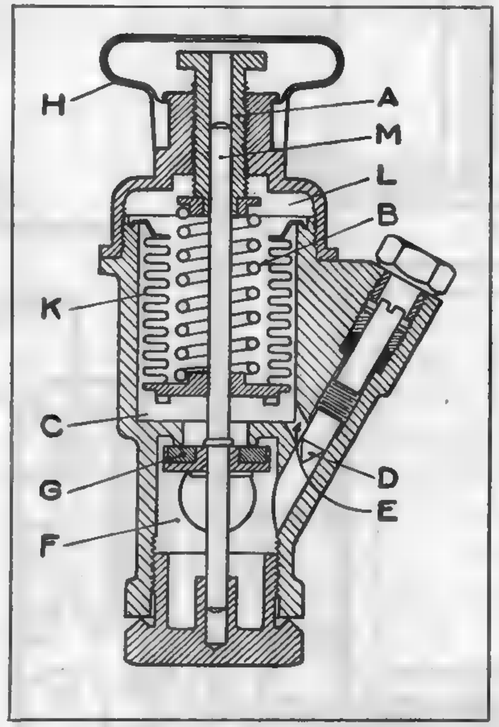


Fig. 244. A compressor suction pressure throttling valve
A. Adjusting spring loading screw; B. Adjusting spring; C. Bellows chamber; D. By-pass valve; E. By-pass orifice; F. Outlet chamber; G. Main valve; H. Soft rubber cap; K. Bellows; L. Atmospheric pressure; M. Valve stem
(Courtesy of: American Injector Company)

line just ahead of the compressor. This surge tank is made large enough that even though the unit is stopped and a two-temperature valve opens, the low side pressure will not build up and start the unit too frequently due to the capacity of the surge tank to absorb pressure changes. The line from

this tank to the compressor must be connected to the bottom of the surge tank to facilitate oil return to the compressor.

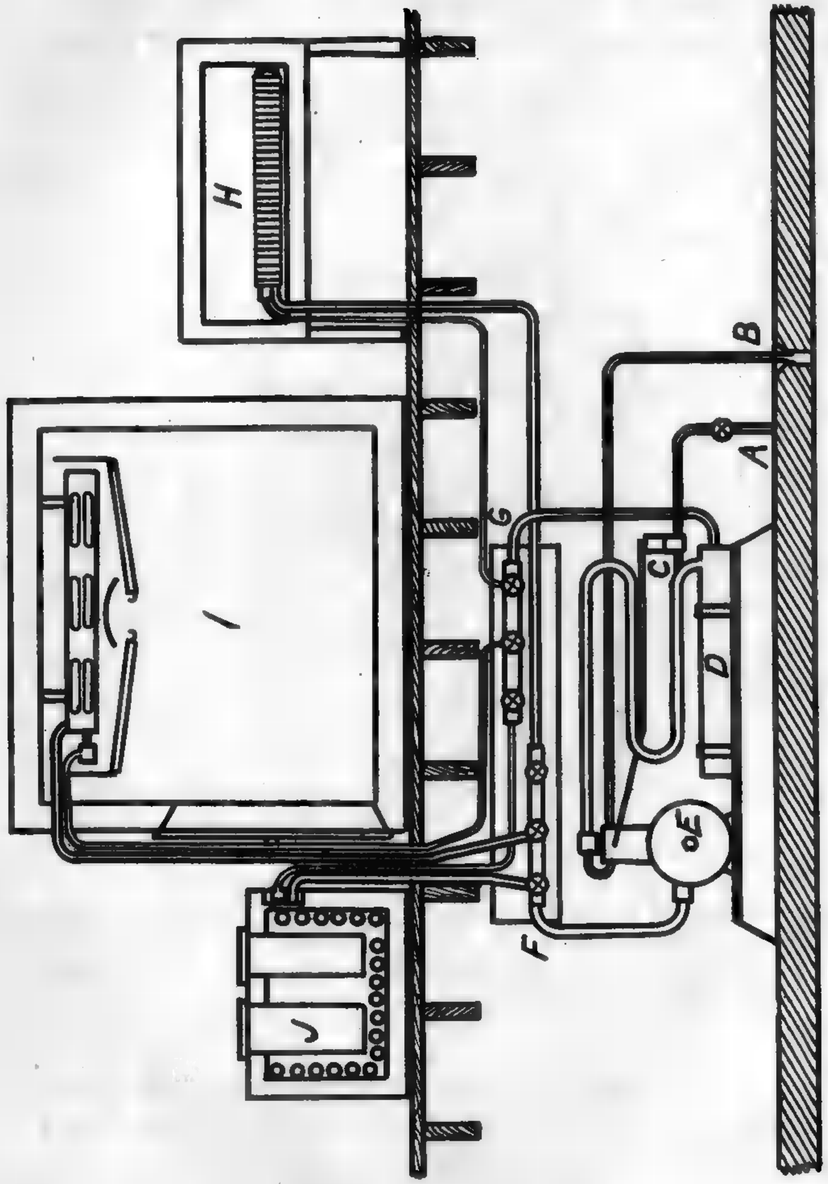


Fig. 245. A typical multiple installation showing the location of the important parts

A. Water in; B. Water out; C. Water valve; D. Liquid receiver; E. Water-cooled compressor; F. Suction line manifold; G. Liquid line manifold; H. Display case; I. Walk-in cooler; J. Frozen foods

Oil separators are often placed between the compressor and the condenser. The oil separator collects the oil pumped over from the compressor and when a certain oil level is reached a float needle opens allowing the oil to be returned to the crankcase of the compressor. Figure 243B illustrates a typical oil separator.

307. COMPRESSOR LOW SIDE PRESSURE CONTROL VALVES:

The starting of a compressor is one of the hardest loads the motor encounters. The inertia of the moving parts and the fact that the crankcase pressure is at a maximum just as the compressor starts necessitates motors of an excess capacity, and even then they are usually taxed to their limit at the moment of starting. A low side pressure control is now being used on some installations which keeps the low side pressures in the crankcase down. Figure 244. It may be termed a reversed metering, two-temperature valve because it never permits the crankcase pressure to exceed a certain predetermined value and if the suction line pressure tends to exceed this value, the valve shuts the suction line off from the compressor. Figure 245 illustrates a multiple installation cooling a walk-in box, a display case and a frozen foods case. Note the location of the two-temperature valves, the check valve, the surge tank, and the low pressure motor control.

308. WATER VALVES:

Practically all the commercial units from ½ H.P. up use a water-cooled condenser wherever water is available. The water circuit must be automatically controlled to reduce the cost of operation. Due to better heat transfer and the lower condenser temperatures and pressures possible in a water-cooled condenser, the amount of power required to drive the condensing unit will be less than for a corresponding sized air-cooled installation. This saving in electrical power com-

pensates to some extent for the cost of the water used. The purpose of the water valve is to turn the water on and off as needed, and also to vary the amount of water as required. The three types of water valves used are the electric type, the pressure type, and the thermostatic type.

309. ELECTRIC WATER VALVE:

The original water valves were of the electric type (1920-

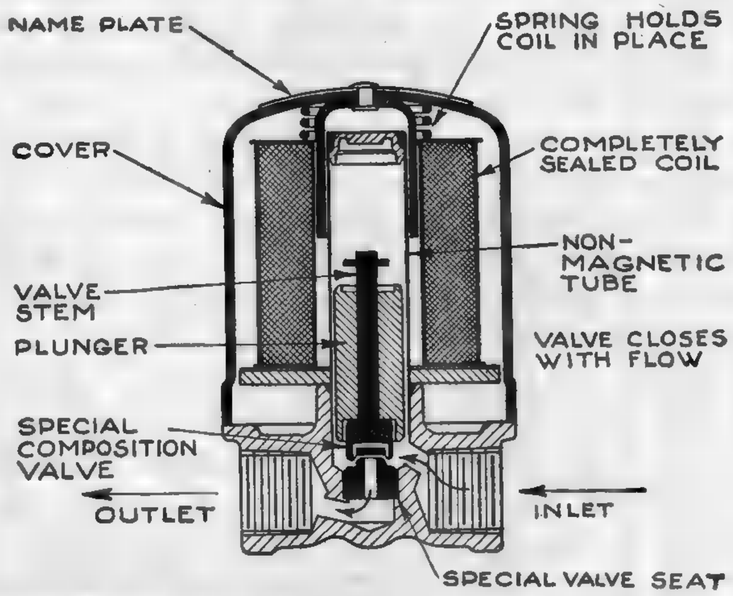


Fig. 246. An electrically operated water valve
(Courtesy of: Automatic Products Company)

24). This valve is operated by a solenoid. The principle of operation is: A magnetic coil is connected in parallel with the electric motor; when the electricity is turned on, this magnet creates a magnetic field; a plunger located in the core of the magnet then moves in attempting to minimize the magnetic resistance. Figure 246. The plunger movement opens the water valve, and the water flows through the condensing coils. The valve is located between the water supply

and the condensing unit and it is usually mounted on the condensing unit. The moment the motor starts, this valve opens. This shuts off the water as soon as the motor is turned off. These electric water valves, because of their inherent construction, consume a small amount of current while they are in operation. This current varies between six and ten watts, but is compensated for by a saving in water consumed. Figure 247 illustrates two typical electric water

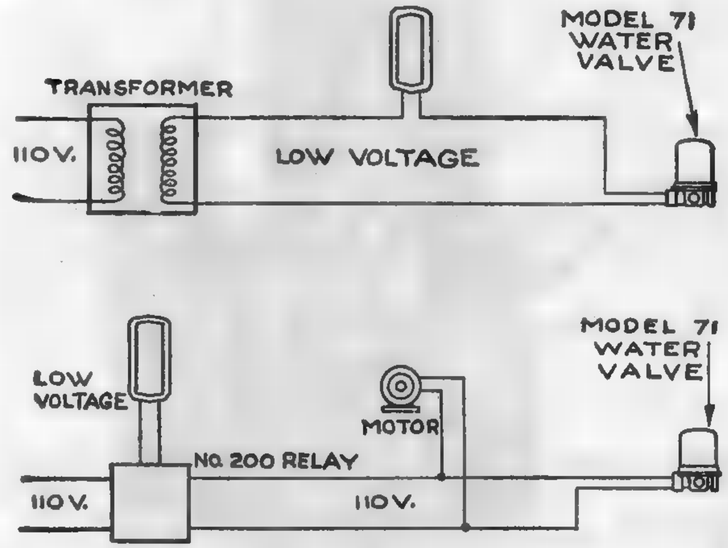


Fig. 247. An electrically controlled water valve wiring diagram
(Courtesy of: Automatic Products Company)

valve hook-ups. On large units a water valve using the by-pass principle must be used as shown in Figure 248. An advantage in the use of the electrically controlled water valve lies in the fact that these valves may be removed or replaced without disturbing the refrigeration system.

All electrically controlled water valves are so constructed that the pressure of the water tends to keep the valves closed.

The valve seats are usually made of brass or bronze and the valve face is of a special rubber composition.

310. PRESSURE WATER VALVE:

The pressure operated type of water valve is becoming popular in the commercial refrigeration field. Its construction consists of a bellows attached to the high pressure side of the

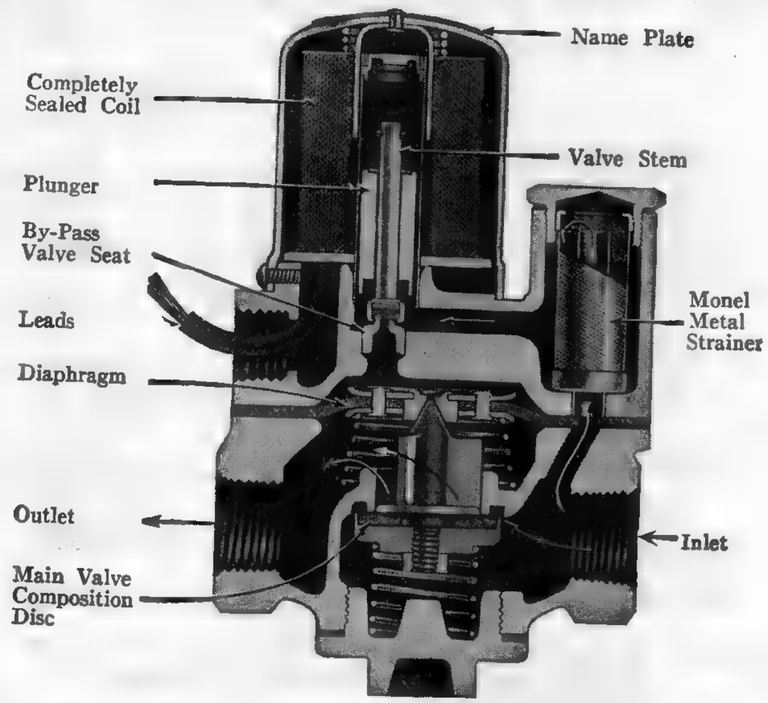


Fig. 248. The by-pass type of electric water valve for large installations
(Courtesy of: Automatic Products Company)

system, preferably to the cylinder head, and this bellows operates a water valve. In operation: As the pressure rises in the condenser due to the accumulation of the gas, the bellows in the water valves expands and by various mechanisms, depending upon the water valve, the valve is opened permitting water to flow into the condenser to cool the com-

pressed gas. It opens the water circuit only when the water is needed, that is, as the pressure rises. Figure 249. It will keep the water flowing just as long as there is a tendency

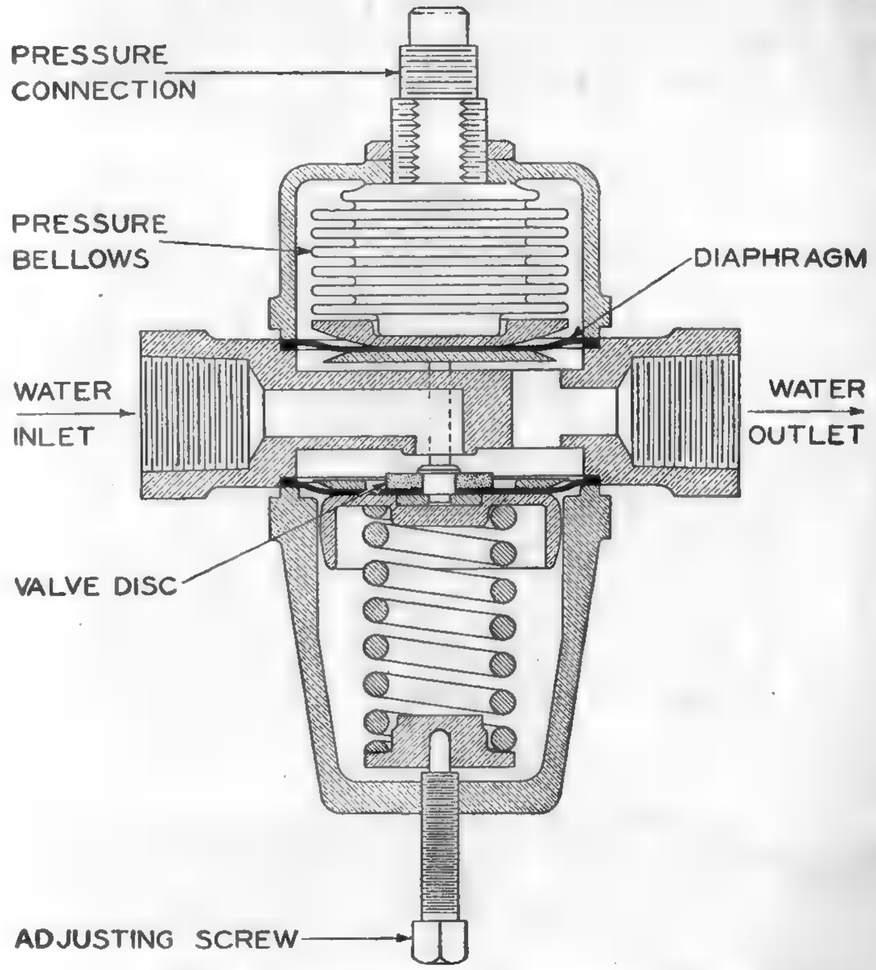


Fig. 249. A Tag pressure operated water valve
(Courtesy of: N. J. Tagliabue Mfg. Company)

for an increase of pressure in the system. These valves are adjusted by the tension of a heavy spring which presses against the bellows. The valves are set to open at certain

definite head pressures, depending upon the temperature of the water and the kind of refrigerant used. See Paragraph 405 for a table of operation pressures. It should be noted that a pressure controlled water valve necessitates a regular service operation to remove the valve from the system. However, the advantages offset this disadvantage because its in-

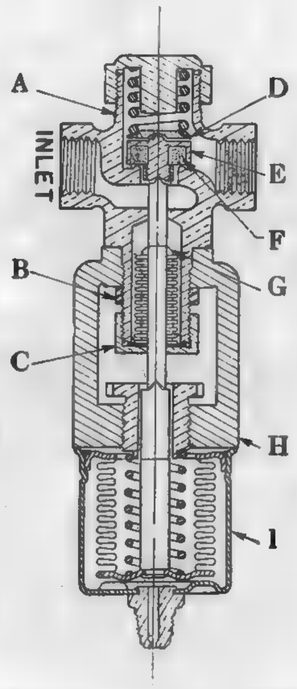


Fig. 250. A Penn pressure operated water valve
A. Body; B. Lock-nut; C. Seal bellows nut; D. Spring disk; E. Valve cap; F. Valve seat; G. Seal bellows; H. Frame; I. Operating bellows housing
(Courtesy of: Penn Electric Switch Company)

herent construction enables a regulated flow of water. As the condensing pressure and temperature increase, the valve opens farther; when the pressures and temperatures drop, the water flow is shut down. Figure 250.

The valves proper are made of a hard rubber composition, bakelite or a fiber, whereas the seat is usually made of copper

or brass. The valves are equipped with either a packing gland or a bellows at the point where the water valve actuating stem goes into the water valve body. The packing construction must be adjusted occasionally to keep it from leaking after a period of time, whereas the bellows, being a sealed mechanism, can only leak if it corrodes through. These

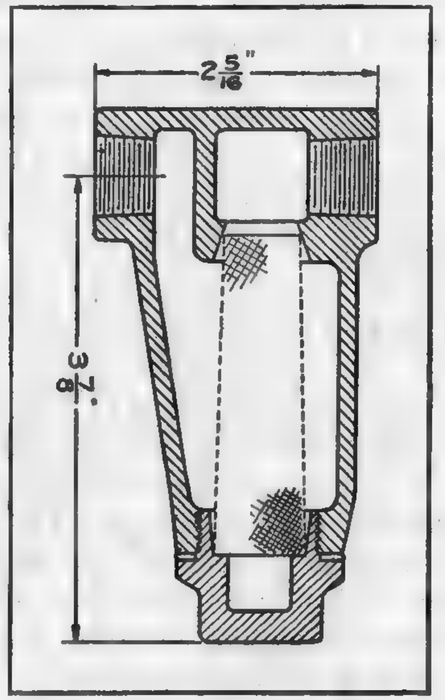


Fig. 251. A water line strainer. The opening in the upper left hand corner is the water into the strainer connection
(Courtesy of: Kerotest Mfg. Company)

valves usually do not depend on the pipe for support, but are provided with the same mounting arrangement or flange. The water-in and the water-out connections are clearly labeled and the valves are usually threaded for 3/8-inch standard pipe. Most of the valves are constructed so that the water pressure tends to keep the valve closed, although this

is not always the case. Both the electric and pressure type should be equipped with filters, that is, they should have screens in the water supply line to remove any solids from the water. Figure 251.

The thermostatic water valve is controlled by the temperature of the exhaust water. The valve proper is identical to the pressure water valve with an addition of a thermostatic element connected to the bellows operating the valve. The element is charged with a volatile liquid. The power bulb is inserted in the water drain at a point just after the water leaves the unit. The pressure created by volatile liquid in the bulb opens the valve when the exhaust water becomes warm and closes the valve as the exhaust water cools.

311. SERVICING VALVES:

Servicing valves used on refrigerating machines enable a service man to determine the operating pressures, to charge or discharge a system, or to remove any part of the system without disturbing the other parts. These valves must be of a sturdy construction and must be designed to withstand continual opening and closing without leaking externally or internally. They should be built to the best advantage to withstand corrosion and deterioration.

312. CONDENSING UNIT VALVES:

The condensing unit is equipped with servicing valves similar to those of the conventional domestic system with the exception that these valves are sometimes constructed larger. That is, the valve stems may be $\frac{3}{8}$-inch across flats, and the gauge connections may be $\frac{1}{4}$-inch pipe instead of $\frac{1}{8}$-inch pipe. This also pertains to the liquid receiver servicing valve, except that some of the units have an extra liquid receiver

servicing valve located between the condenser and the liquid receiver.

313. INSTALLATION VALVES (HAND SHUT-OFF):

In addition to the usual service valves, multiple code installa-

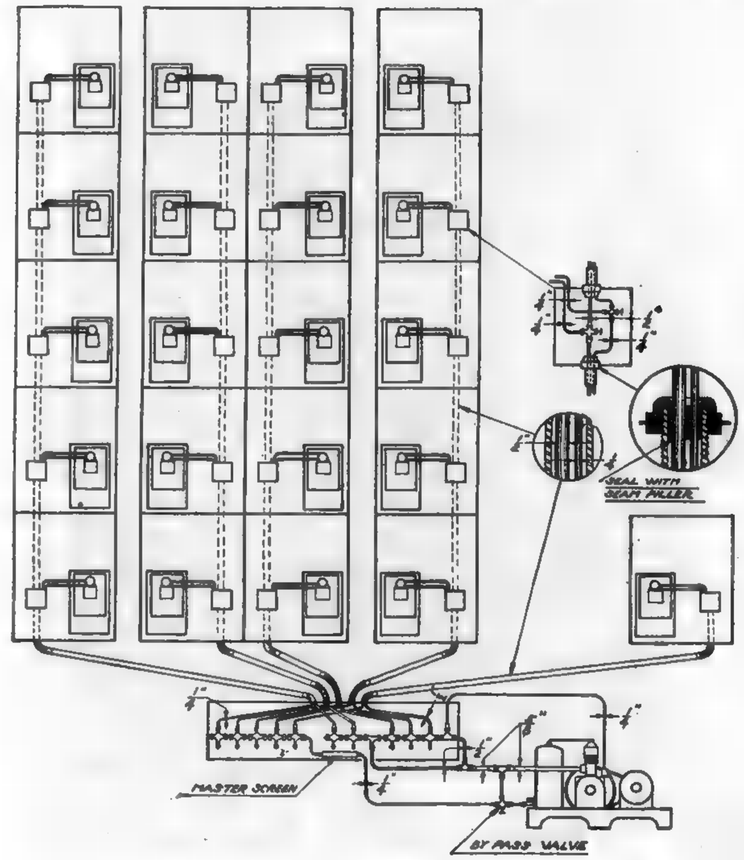


Fig. 252. A multiple system installation which complies with the National Refrigeration Code
(Courtesy of: Kelvinator Sales Corporation)

tions are also equipped with what are termed hand shut-off valves. These valves are required by law to be so located that they may be manipulated easily and readily accessible. They may be classified as riser valves or manifold valves. In multi-

ple installations it is very convenient to run the suction line from the compressor to a drop forged or cast-brass pipe and then to have the individual suction lines for each cooling unit go from this manifold to the coils. Between each of

Fig. 253. A packless three-way riser valve. Note the strap used to mount the valve in a cabinet or on a panel
(Courtesy of: American Injector Company)

these suction lines and the manifold, and mounted into the manifold, is a hand operated shut-off valve. This permits any one of the suction lines to be closed without interfering with the operation of the others. A similar manifolding device is also provided for the liquid line. Figure 252. Instal-

lation usually provides for the mounting of this valve grouping in a steel box or cabinet.

814. RISER VALVE:

Another type of valve, which is used as a shut-off valve and which is also termed a riser valve, is a hand operated valve with three openings to which refrigerant lines may be connected. Two of these openings are in line with each other on opposite sides of the valve, while the third one is a little closer to the valve wheel and is at right angles to the other two openings. By screwing the hand valve in, the opening at right angles to the other two is closed. This construction permits mounting the valve in either a liquid or suction line, enabling one to connect a second coil to it which may be disconnected at any time from the remainder of the system by screwing the valve all the way in. All service valves are of the drop forged construction to minimize seepage through the valve. The valve stem may be of either brass or steel, with steel being quite popular. The packing around the valve stem may be asbestos, lead, and graphite, or the valve may be of the packless type. At present the packless type valve, meaning the type which uses a bellows as a sealing device rather than a packing, is becoming popular. Figure 253. Many of the new valves have self-seating features. This means the valve is easily seated again by tapping the valve stem into the seat. The valve seat is made of a soft lead alloy or Monel metal.

815. TUBING AND FITTINGS:

The tubing used in commercial refrigeration is usually the seamless, dehydrated, annealed, .035-inch wall thickness, copper tubing, but for air-conditioning work and for many of the larger installations hard drawn copper pipe is becoming

quite popular. This pipe is furnished in iron pipe sizes and the fittings are not interchangeable with those tubing sizes. Where tubing is run into cabinets and in brine solutions, tinned tubing should be used to minimize corrosion. The tubing may be attached to the fittings in the smaller units by means of the 45° S.A.E. flared connection. In the larger installations where this type of connection would be awkward to make and because of the growing use of hard drawn copper pipe, streamline soldered connections are used. Soldered and flange fittings are recommended in cabinets and when submerged in brines because of the danger of frost accumulations under a flare nut, which tends to pinch the tubings. In most multiple installations, the tubing is run through solid conduit of the thin wall type; all the bends should be made in Greenfield (flexible tubing), or the bends are eliminated entirely by the use of fittings (elbows and tees) installed inside steel boxes. See Chapter XV for detailed instructions on code installations.

316. MOTORS:

Electric motors have become the most used means for driving the different refrigerating mechanisms, and the various types of motors used warrant a word of explanation here. The 110 and 200 volt motors, single phase, are the most popular. In practically all of the installations the repulsion-start induction type of motor is the most used, whereas in large installations, for instance air-conditioning, polyphase motors are used wherever possible. The electric wiring installation for these motors must be done by a licensed electrician in code localities.

The multiple belt drive is practically the only one used, although the direct drive is increased in popularity and gear drives have been tried. The belt drive utilizes the belts in

groups of two or more. These belts are usually of the V-construction and have proved their merit by many years of service. The complete condensing unit is usually mounted on a frame. The apparatus must be very firmly bolted to the floor, usually by means of bolts set in cement. When specifying motor equipment it is well to determine the specifications of the current supply on the premises before writing the motor specifications.

317. TRUCK SYSTEMS:

A popular method of transporting perishable produce is by means of trucks especially built for that purpose. These trucks have many variations in application, but the systems used to produce refrigeration may be divided into three main types.

1. Ice
2. Dry ice
3. Mechanical

The ice method is used, but because of weight and loading is decreasing in popularity. The use of dry ice is increasing because of the weight reduction, and the drainage problem is eliminated. However, some difficulty is encountered in controlling the temperatures.

Mechanical refrigeration comprises the typical refrigerating unit in most cases, the major variation being in the nature of the compressor drive. These drives are:

1. Engine driven electric generator and motor.
2. Driven off the transmission shaft.
3. Separate gasoline engine.

(1) and (3) are the most popular because they permit constant compressor speed and consistent refrigeration even though the truck is parked. The generator and motor use voltages, cycles, and phases which enable plugging the motor

into a wall plug in the garage if it is desired to keep the truck cold over night. The gasoline engine driven units are automatically controlled to start and stop as the system requires. Figure 254.

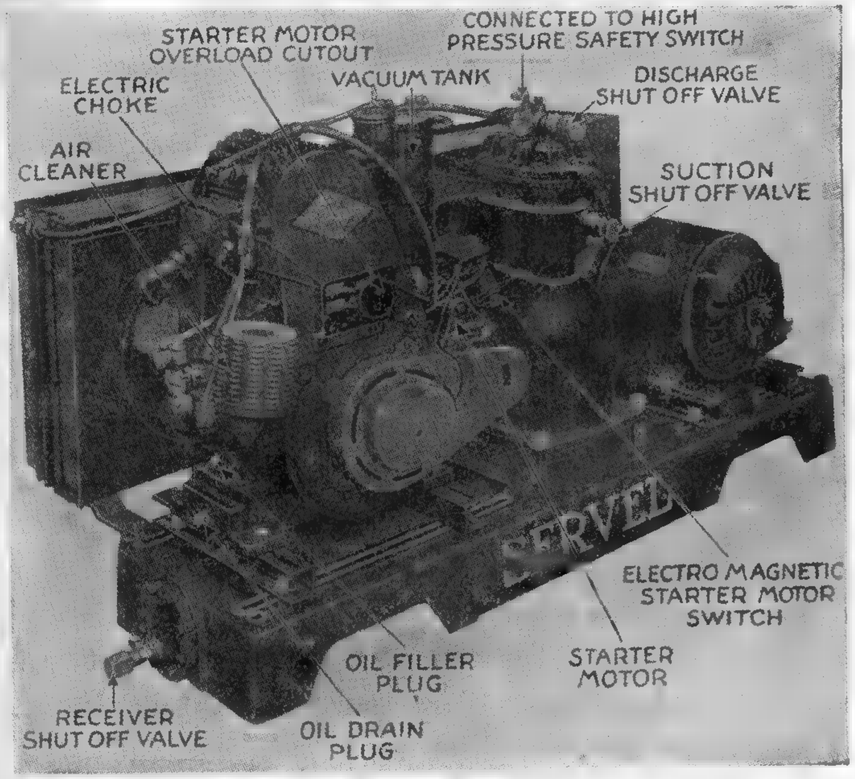


Fig. 254. A refrigerated truck showing combination motor and engine drive unit

(Courtesy of: Servel Sales, Inc.)

318. TRAIN SYSTEMS:

Two different types of refrigeration systems are used on trains. These are freight refrigeration and air-conditioning in passenger cars.

Freight refrigeration may be by means of water ice, dry ice, or mechanical refrigeration. The present trend is to-

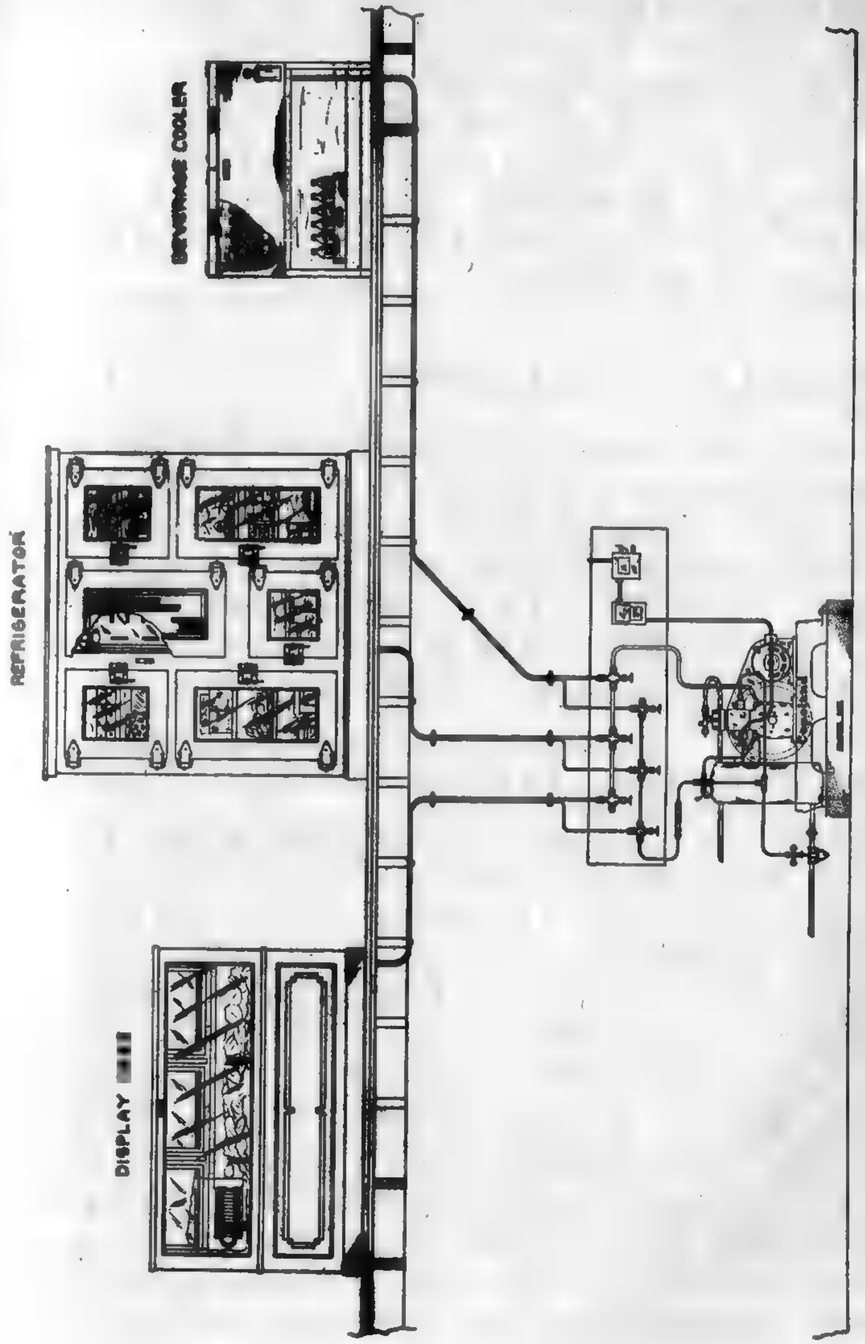


Fig. 255. A typical grocery store refrigeration installation

(Courtesy of: Copeland Sales Company)

ward mechanical refrigeration. Passenger car air-conditioning is mainly by mechanical refrigeration.

The compressors, in mechanical installations, are usually driven from the car axle while the cars are in motion and by an electric motor while the cars are in the yard.

Some train refrigeration systems have been developed using the absorption system. Others have employed the steam jet system of refrigeration.

319. MULTIPLE INSTALLATIONS:

All of the unit equipment explained in the first part of this chapter is connected in multiple in certain refrigerating installations. A market installation having a walk-in cooler, a display case, and a frozen foods cabinet is a typical example. Figure 245. The illustration shows a condensing unit (water-cooled), located in the basement and connected by a manifold system to the three cabinets.

320. GROCERY STORE INSTALLATION:

A grocery store will most frequently have a grocery cabinet and a display counter; some of them also use a beverage cooler. Figure 255. The grocery cabinet coil (wet or dry system) may be mounted in the coil chamber placed overhead and will be a flat coil if the cabinet is especially designed for mechanical refrigeration. If the cabinet is an ice conversion cabinet the coil may be a deep coil in the center, or in the upper left, or in the upper right hand corner of the cabinet. The door to this chamber is usually equipped with a mirror front. The coil is usually suspended from the ceiling of the cabinet and the refrigerant lines come into the cabinet through a hole in the rear wall. This hole is sealed with a sealing tar, plastic wood, etc. The tubing is usually installed

in conduit as soon as it leaves the cabinet and hand operated, shut-off valves are located immediately at the cabinet or just before the lines connect to the mains. The display counter may be any of the various types of counters, but usually the rear bunker type or the end bunker type is used. The tubing reaches the coil through a hole located in one end in the bottom of the case if it is the rear bunker type and in the back near the floor if it is the end bunker type. The beverage cooling cabinet is usually cooled by a coil of plain tubing immersed in sweet water.

321. A MARKET INSTALLATION:

A meat market usually has refrigerating equipment of the following nature: a large walk-in cabinet used for the storage of large cuts of meat and for overnight storage of all the produce, and one or more display counters used to contain the produce during the day. Occasionally, one will find a meat market using a grocery cabinet as a storage for butter, eggs, milk, etc. As explained previously, a walk-in cooler is usually a very large cabinet maintained between 36°F. to 40°F., while the display counter, being used only for temporary storage of the food, is kept between 45°F. to 50°F. The grocery cabinet is kept at 42°F. to 45°F. These three refrigerating cabinets are usually connected in multiple, the installation being typical in every respect. However, in some cases where the display counter and the walk-in cooler are considerably out of proportion one to the other as to their refrigerating capacity, a snap action, two-temperature valve must be placed in the suction line of the display counter coil to produce constant refrigeration. The display counters are of various types and the coil mountings in them vary considerably according to the type of counter being used. Figure 198.

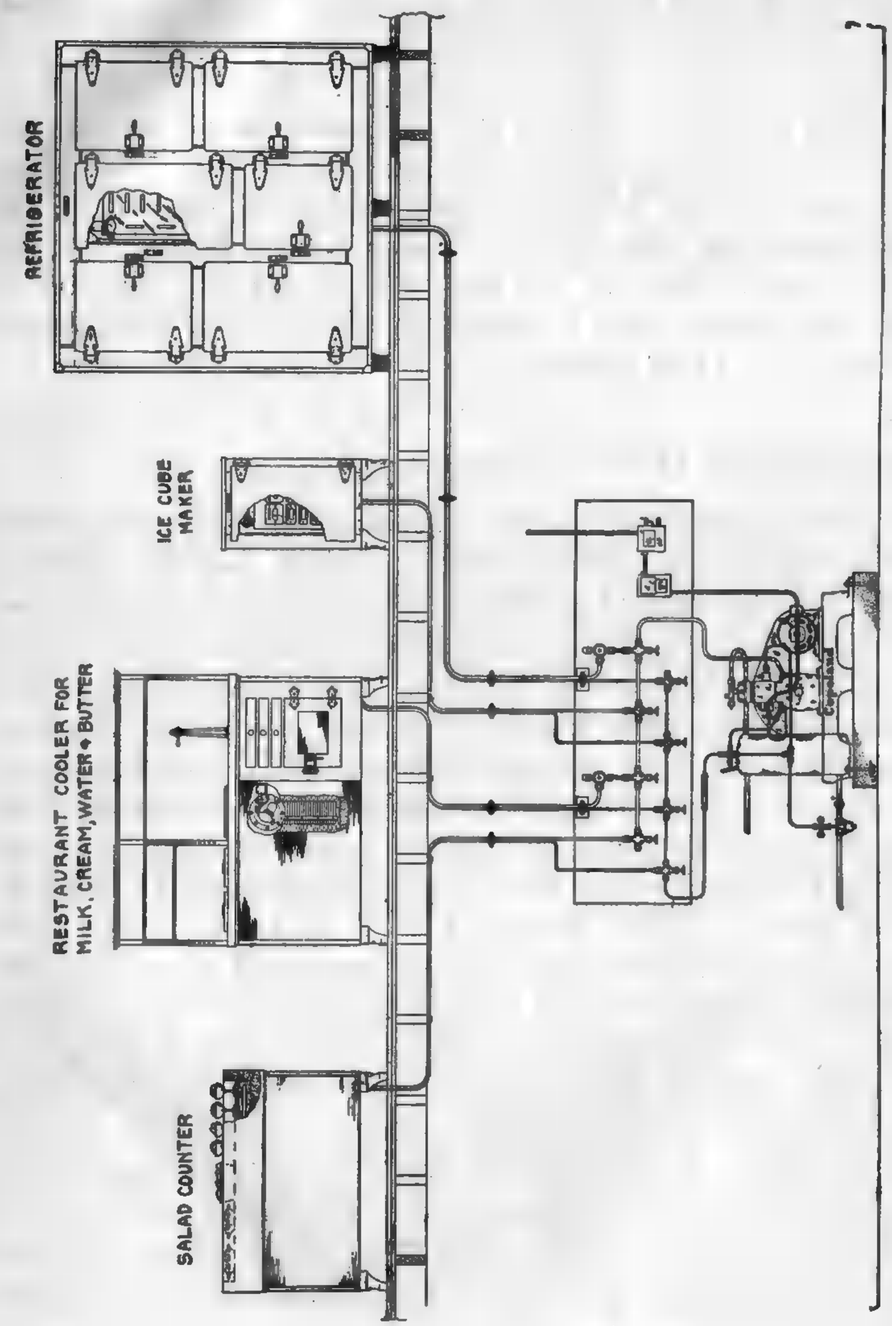


Fig. 256. A typical restaurant refrigeration installation
(Courtesy of: Copeland Sales Company)

822. THE RESTAURANT INSTALLATION:

A restaurant may use several types of refrigerating cabinets, among them being a grocery cabinet used for general storage purposes, or if the restaurant is large enough, a walk-in cooler; a water cooler; an ice cream cabinet; a salad pan; and occasionally an ice cube maker. Due to the policies of some creamery companies, the ice cream cabinet will usually be found to have its own individual condensing unit, but occasionally one will find all of these various devices connected to one common condensing unit. An installation of this nature should have two-temperature valves because the ice cream cabinet is to be kept at 5°F., the ice maker cabinet at 15°F., the water-cooler at approximately 28°F., the salad pan at 25°F., while the walk-in cooler or grocery cabinet has various coil temperatures depending upon the type of coil used. If possible, the various refrigerant temperatures for the different pieces of apparatus should be grouped together. That is, the salad pan and the water cooler may use the same back pressure and this low side pressure may also be used for the walk-in cooler if it has a non-frosting coil. The ice cream cabinet is to be kept at a very low temperature, and the installation will usually need a two-temperature valve controlling the ice cube maker and another two-temperature valve controlling the other three listed above. It is only very rarely that an installation will be found wherein the ice cube maker and the ice cream cabinet are run at the same refrigerant back pressure. Figure 256.

823. SODA FOUNTAIN INSTALLATIONS:

One of the first applications of commercial refrigerating equipment of the automatic type was in ice cream retail cabinets. Out of this start gradually developed the soda fountain installation which involves the ice cream cabinet

using one or more coils used to refrigerate the ice cream and using one or more coils to cool the beverages. In small installations, two coils are usually used. One coil is used for the ice cream which is maintained between 0°F. and 5°F. The other coil is usually a submerged sweet water bath type and refrigerates the various beverages served at a soda fountain, such as water, ginger ale, carbonated water, and syrups. These beverages are usually maintained at 40°F. to 45°F.

Large installations of this nature will use one coil to refrigerate the brick ice cream at 0°F., another coil to refrigerate the chocolate and fruit ice creams at 5° F., and still another for the vanilla and nut ice creams which are usually kept at from 10°F. to 12°F. The beverages are all kept at approximately the same temperature and the number of coils depends upon the number of beverages to be handled.

When all of these various cooling coils are connected in multiple to a condensing unit, two-temperature valves are imperative. The metering type two-temperature valve is satisfactory for this purpose because of the large temperature differences. Occasionally, if the installation is large enough, a two-temperature valve may be installed in the vanilla and nut ice cream cooling coil suction line because its temperature is maintained approximately 10°F. above that of the coldest coil, i.e., the brick ice cream cooling coil. These two-temperature valves are usually located near the condensing unit on the same board that holds the manifold valves. This type of valve naturally has to be mounted close to the coil that it controls. Figure 212.

324. FLORIST'S INSTALLATIONS:

The florist's cabinet is a large walk-in cooler equipped with large windows. The temperatures maintained in the cabinet are between 52°F. and 57°F., and a very high humidity is

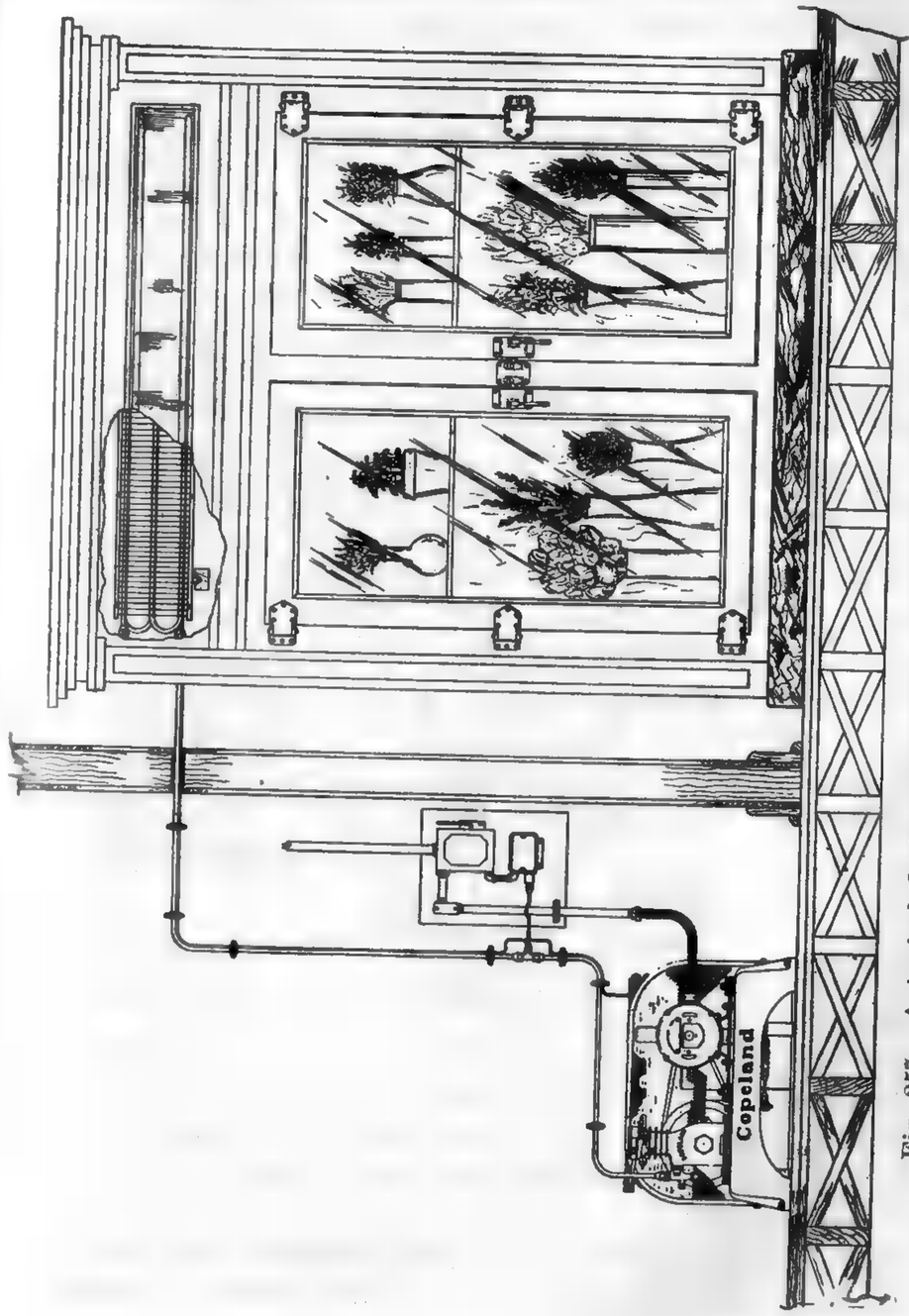


Fig. 257. A typical florist refrigerator installation. Note that the pressure motor control is connected to the suction line
(Courtesy of: Copeland Sales Company)

necessary. This installation is usually a single one and no special instructions or precautions are necessary. The cooling coil must be of an excess capacity for this size box because it must maintain humidities of between 85 per cent and

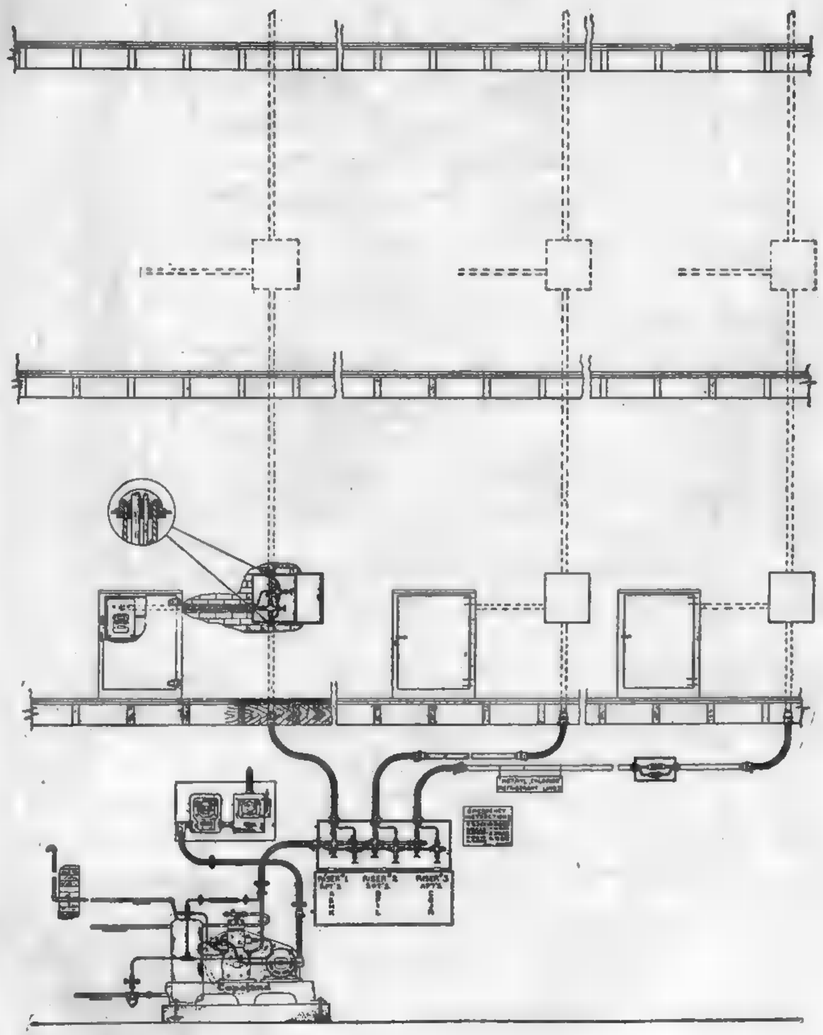


Fig. 258. A typical code apartment house installation
(Courtesy of: Copeland Sales Company)

90 per cent. Figure 257. A large coil will require less temperature difference than a small coil for the same refrigerating effect; therefore it will have a lesser tendency to condense moisture from the air.

825. APARTMENT HOUSE INSTALLATIONS:

Most of the apartment houses in large cities have refrigerators of one kind or another located in each apartment. By far the most popular of these is the multiple installation using large condensing units and a separate cooling coil in each apartment's refrigerator cabinet. These installations may be divided into two classes: (1) those with the tubing not protected (non-code), and (2) those having the refrigerant tubing run in conduit and the valves located in steel boxes for protection (code). In the code installations manifold valves are used to control each vertical run of refrigerant tubing and these valves are located either at the condensing unit or at the point where the tubing starts to leave the basement. The manifold type of installation is the recommended one at the present time. A water-cooled condensing unit is preferable for this type of installation. Figure 258.

826. MILK COOLING INSTALLATIONS:

Due to the pure food laws in most of the states, a farmer must have refrigeration equipment unless he is provided with very cold well water or a good supply of natural ice. These pure food laws demand that the temperature of the milk be reduced to 40°F. within two hours after having been drawn from the cow in order to be listed as certified or Grade A milk. The two pieces of equipment used to perform this duty are the aerator and the storage cabinet. The aerator is a

vertical run of tubing through which refrigerant brine is passed and over the outside of which milk is poured. Figure 259. The design permits instantaneous cooling of the milk and at the same time permits a thorough cleansing of the milk cooling surfaces to maintain sanitation. These aerators are usually specially constructed by manufacturers and their sizes naturally vary with the amount of cooling to be done, i.e., this size is based upon the number of gallons of milk per hour to be cooled.

Fig. 259. A tubular milk cooler (aerator)
(Courtesy of: Cherry-Burrell Corporation)

The milk storage cabinet may be of two types; one is called the submerged or wet type in which a lift-top cabinet is used. This lift-top cabinet is approximately half filled with water and is cooled by a refrigerant coil running along the inside walls of the tank. The milk, as it has been cooled in the aerator, is put in 5- or 10-gallon milk cans and submerged in this refrigerated water. The other method is to have a typical storage cabinet (dry method), and after the milk has been cooled in the aerator, it is put into bottles or

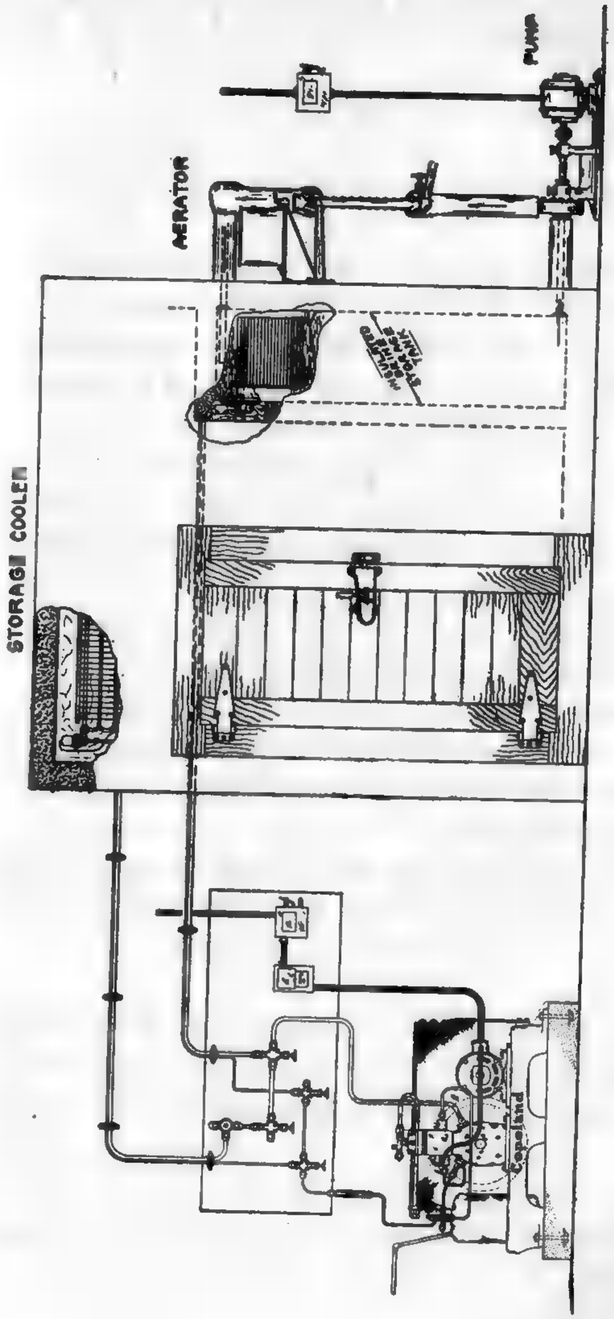


Fig. 260. A milk cooling or dairy installation using an aerator and a dry storage refrigerator cabinet. Note the two-temperature valve
(Courtesy of: Copeland Sales Company)

into cans and stored in this typical refrigerator cabinet until needed. Figure 260.

327. REVIEW QUESTIONS:

Answers to the following questions may be found on page 824.

1. What cabinet temperatures are recommended for the following commercial installations, water-cooling, walk-in coolers, florist's cabinet, and ice cream cabinet?
2. Why is it necessary that the doors and windows in these cabinets be air-tight?
3. What is the purpose of dead air spaces formed between the two and three pane windows in these cabinets?
4. How is moisture kept out from between multiple pane windows?
5. Why are the lights of the display counters usually located outside of the counter?
6. If one were to mount a thermometer in one of the walk-in cabinets, where would one find the average temperature?
7. Why are most commercial refrigeration installations of the multiple type?
8. To what temperature would you permit water to be cooled, (*a*) if the bubbler was located in the heat treating room of a tool and die factory? (*b*) in an office building?
9. Why does the length of the counter affect the number of end bunkers in an end bunker display cabinet?
10. Why must the humidity be kept very high in produce storage cabinets?
11. What is a thermostatic expansion valve?
12. Which refrigerant control uses the most refrigerant?
13. What are the advantages of the non-frosting cooling coils?

14. Is the flared, or the soldered flanged, tubing connection the best for inside a refrigerator cabinet?
15. Why must high pressure motor cut-outs be used for water-cooled condensing units?
16. Where are the intake valves of a compressor usually located?
17. Why is it advisable to connect the high pressure motor cut-out into the cylinder head of the compressor?
18. Name the three types of water valves.
19. Name the various two-temperature valves.
20. What are the advantages of water-cooled condensers? Air-cooled condensers?
21. What are the advantages claimed for forced circulation cooling coils?
22. List the various temperatures maintained at a soda fountain.
23. Why is the pressure type motor control usually used in multiple installations?
24. In multiple installations which use two-temperature valves, where should the check valves be placed?
25. What per cent of a refrigeration load may be placed on a coil controlled by a two-temperature valve?

CHAPTER XIV

COMMERCIAL REFRIGERATION CALCULATIONS AND HEAT LOADS

Most commercial refrigeration installations are refrigeration engineering problems. Four steps are required in the solution of a refrigeration installation problem.

a) The total amount of heat (heat load) that must be removed

b) The selection of a condensing unit to handle the heat load

c) The selection of a coil or cooling unit which in connection with the condensing unit will furnish the refrigeration desired

d) The installation of the system, which must consider such factors as water supply, temperature control devices, refrigerator line sizes, air circulation, and humidity control, codes, etc.

In determining heat loads two factors must be considered; these are:

1. Insulation or heat leakage into the box or container. This is affected by the amount of exposed surface, the thickness and kind of insulation, and the temperature difference between the inside and outside of the box.
2. Usage or service in the temperature of the articles put into the refrigerators, their specific heat, generated heat, and latent heat as the requirements demand, also the factors of the nature of the service required such as the number of times per day that the doors of the refrigerator are opened, heat generated inside by fans. lights, and other electrical devices.

The selection of a condensing unit is usually made from manufacturers' tables of capacities. Cooling coils are se-

lected from specifications for capacities, and are selected to balance the capacity of the condensing unit. Also the type of temperature control, the arrangement for air circulation, and specific duty affect the selection of a coil.

The installation of all commercial refrigeration equipment involves technical understanding of all the factors and is a determining factor in the successful operation of the system. The following paragraphs on commercial refrigeration are aimed to lay a foundation on the process of specification and installation of commercial refrigeration equipment.

828. HEAT LOAD:

The total heat load consists of the amount of heat to be removed from a cabinet during a certain period. This is dependent on two main factors:

1. The heat leakage load
2. The heat usage or the service load.

829. HEAT LEAKAGE VARIABLES:

Various research organizations throughout the world have experimented to determine the factors of heat leakage through walls; refrigeration companies have spent considerable time perfecting means whereby we can be absolutely sure of the quantity of heat that leaks into definite kinds of containers for refrigeration. The five factors that affect heat leakage are:

1. The time
2. The temperature difference
3. The thickness of the insulation
4. The kind of insulation
5. The external area of the cabinet

a) The longer the period of time, the more heat will leak through a certain wall. The standard time

unit used for computation is the 24-hour period, although a few prefer the 1-hour period.

b) The difference in temperature is an important factor in the heat leakage of a container. The greater the temperature difference the more heat will leak through the wall. One might compare this idea to pressure: the more pressure the more gas or water will flow through an opening.

c) The third variable is the thickness of the insulation. The thicker the insulation, the less heat will flow through it. Twice as much heat will leak through a wall that is insulated with 1 inch of insulation as will flow through a wall having 2 inches of insulation.

d) The kind of insulation or the material used is one of the most important considerations in the construction of these containers. Cork, for instance, will insulate approximately four times better than wood and eight or nine times better than brick, etc.; on the other hand some insulations are more costly than others and this must be taken into consideration. Paragraph 441 gives tables of relative insulation values of common substances.

e) Just as the size of the pipe determines how much water will flow through it (the bigger the pipe the more water will flow), so the more the area through which heat may leak the greater the heat flow. The common unit used for determining heat flow is the square foot of area. This area is always taken as the outside of the container, although to be exactly accurate one should use an intermediate area.

330. HEAT LOAD (LEAKAGE):

To bring together all the variables mentioned above, standards have been developed and are now being used by the various refrigerating companies. All of these variables have been reduced to unit values, and the heat leakage of the wall is first determined for these unit values. The unit or basic values are obtained from a slab of the insulation 1 square foot in area, 1 inch thick, with a temperature difference of 1°F., and over a period of time of either 1 hour or 24 hours. The values obtained represent the heat flow through the slab under these conditions and naturally vary only with

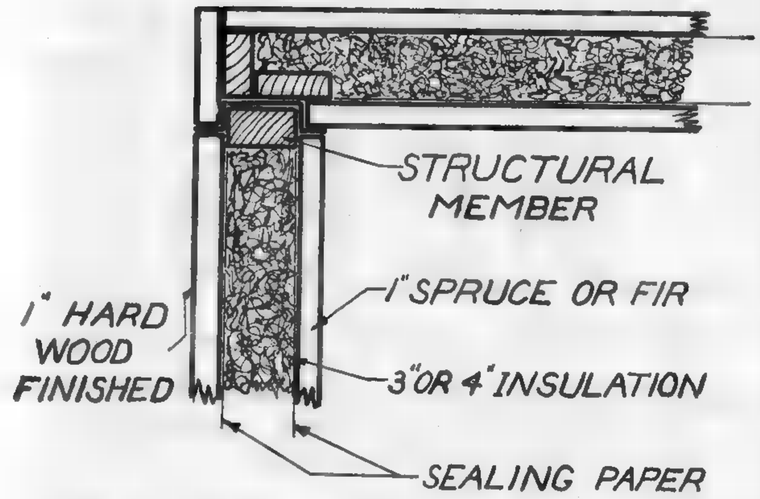


Fig. 261. A cross section of a walk-in cooler wall
(Courtesy of: McCray Refrigerator Sales Corporation)

the kind of insulation. This value is called the (K) factor of the slab, and is in B.T.U.'s per square foot, per degree F., per 24 hours or 1 hour, per 1 inch thickness. Paragraph 441. Basically the following formula will give the heat leakage into any kind of container:

$$\text{B.T.U.} = \frac{\text{sq. ft.} \times \text{K} \times \text{temperature diff.} \times \text{time}}{\text{thickness of insulation in inches}}$$

This formula deals with one kind of insulation only, in order to compute the heat leakage through a composite wall, such

as a wall made out of wood and cork or wood and metal. Figure 261. The formula for computing the common K factor is shown and explained in Paragraph 453A.

This type of computation is very complicated as one can readily see; therefore standard tables for computing heat leakage have been developed.

Temperature Difference in Degrees Fahrenheit	Insulation Thickness (Cork or Its Equivalent)				Glass	
	2½ in.	3 in.	3½ in.	4 in.	Double Thickness	Triple Thickness
40°	84.0	72.0	64.0	60.0	440.0	280.0
50°	105.0	90.0	80.0	75.0	550.0	350.0
60°	126.0	108.0	96.0	90.0	660.0	420.0
70°	147.0	126.0	112.0	105.0	770.0	490.0
80°	168.0	144.0	128.0	120.0	880.0	560.0
90°	189.0	162.0	144.0	135.0	990.0	630.0

These tables are based on the use of a layer of wood, both inside and outside of the cork. If wood is not used on both sides, consider that the insulation is one-half inch less than the actual thickness.

Fig. 262. Heat leakage values through refrigerator wall (B.T.U.)
(Courtesy of: Fedders Mfg. Company)

331. TABULAR METHODS OF DETERMINING HEAT LEAKAGE:

A method for determining the heat leakage into a cabinet, such as used by the Kelvinator Corporation and Fedders Company, is shown in Figure 262. The valves are based on actual experiments and investigations, and practice has shown their accuracy. The National Electrical Manufacturers Association (N.E.M.A.) have developed a tentative standard for determining the heat load on refrigerator cabinets. The method they recommend is shown in Figure 263.

One will note that tables for the heat leakage of glass are included in Figure 263. Many of these refrigerator cabinets are equipped with windows. The tables show that the heat leakage through the windows is very high compared to the leakage through the walls.

To use the tables, proceed as follows (using a butcher or walk-in refrigerator box as a sample problem): The sales

Thickness of Insulation	Approximate Wall Thickness, In.	Overall Transmission Factor			No. of panes of glass	B.t.u. /sq. foot /hr.
		A	B	C		
2	4	.125	.165	.205	1	1.13
2½	4½	.112	.148	.184	2	.46
3	5	.100	.132	.164	3	.29
3½	5½	.091	.120	.149	4	.21
4	6	.083	.110	.136	.....	.....
4½	6½	.077	.102	.126	.....	.....
5	7	.072	.95	.118	.....	.....
5½	7½	.067	.88	.110	.....	.....
6	8	.063	.83	.103	.....	.....

(Courtesy of: American Society of Refrigerating Engineers)

A. Corkboard, Balsam Wood, Celotex, Ground Cork, Insulite, Kapok, Linofelt, Mineral Wool, Palco Bark, Rock Cork, Etc.; B. Sawdust, Shavings, Lithboard; C. Wood, Cotton Steel Hulls, Rice Chaff, Strawboard

Fig. 263. Overall Heat Transmission Factors—Btu. per Hr. per °F per Sq. Ft.

engineer visits the establishment and determines all the data possible concerning the cabinet and the service. For instance, he must determine the exterior dimensions of the box, the dimensions of the windows, the dimensions of the wall, the thickness of the insulation, the kind of insulation, the number of panes in the windows, how much business the butcher does, what temperatures the butcher desires in the cabinet, and what the average summer temperature is for the locality, and also the highest possible water temperature if a water-cooled installation is to be made.

332. CABINET AREAS:

With this data he may calculate the following: the exterior dimensions of the cabinet (the width and the length are multiplied together and then multiplied by two; these areas represent the floor and the ceiling of the box; the width and the height are then multiplied together, and multiplied by two to determine the area of the ends of the box; the length and the height are multiplied by two to determine the area of the ends of the box; the length and the height are multiplied together, and then multiplied by two to take care of the sides of the box). Add the three values obtained and the total external area of the box is obtained. By formula:

L = Length W = Width H = Height

(1) W × L × 2 = Area of top and bottom
(2) W × H × 2 = Area of ends
(3) L × H × 2 = Area of sides
Total external area = Sum

The reason most companies base their computations on the external area of the box rather than the interior area or medium area is that the results are on the safe side. Also this method compensates somewhat for breaks in the insulation due to the construction of the cabinet. Likewise, these cabinets often have wood corners and wood beams along the walls to reinforce the paneling and this wood is not a good insulator. After obtaining the external area of the box, one must subtract the window area to obtain the true area of the insulated surface. Window areas are calculated from the measurements of the outside edges of the window frame and must be considered separately.

The total external area — the window area = the insulated area.

From the tables (Figure 262) one may easily find the amount of heat that will leak through the insulation per square foot of area for that particular type of wall construction. For example, if the wall is made of 1 inch lumber paneling on both sides and 3 inches of slab cork between, the tables will reveal that at a temperature difference of 50°F., 90 B.T.U. will leak through per square foot during the period of 24 hours. The glass leakage table will similarly give values for the heat leakage through 1 square foot of glass. Multiply these unit values by the total area of each and the sum of the two will give the total heat leakage into the cabinet.

A typical example is a 6 feet × 7 feet × 10 feet walk-in cooler with two windows 1½ feet × 2 feet. The box is kept at 36°F. in a room with an average temperature of 86°F. The wall construction consists of 3 inches cork with 1 inch lumber on each side. The windows are of the double pane construction.

Total surface
Walls: 6 × 7 × 2 = 84 sq. ft. (ceiling and floor)
6 × 10 × 2 = 120 sq. ft. (ends)
7 × 10 × 2 = 140 sq. ft. (sides)
344 sq. ft. total area

Windows: 1½ × 2 × 2 = 6 sq. ft. of window
344 — 6 = 338 sq. ft. of insulated wall
1 sq. ft. of the wall allows 90 B.T.U. per 24 hrs.
90 B.T.U. × 338 sq. ft. = 30,420 B.T.U. per 24 hrs. through the walls.
1 sq. ft. of the windows allows 550 B.T.U. per 24 hrs.
550 B.T.U. × 6 sq. ft. = 3,300 B.T.U. per 24 hrs. through the windows.
30,420 + 3,300 = 33,720 B.T.U. Total per 24 hrs.

333. HEAT LOAD (USAGE):

The total heat load of the refrigerator cabinet in addition to being dependent upon the heat leaking through the walls and

windows is also affected by the heat to be removed from articles in the cabinet and air change. This heat is called the heat usage, or the service load, and it is caused by the changes of air in the cabinet, by the produce to be cooled, by the lights and motors which may be used inside the box, and by the occupancy of the box.

Refrigeration equipment manufacturers have developed a standard whereby one may obtain a fairly accurate estimate of the usage heat load. The method is as follows: The box is classified as to the type of service to be performed, and under this classification come florist's cabinets, grocery boxes, normal market coolers, fresh meat cabinets, and restaurant short-order boxes. From experience these companies have found that such boxes used for the same general line of business hold rather consistently to the same usage heat load. This load depends in detail upon the following basic factors:

1. The temperature difference between the exterior and the interior of the cabinet
2. The volume of the cabinet (internal)
3. The type of service
4. The time

It is possible to calculate usage by using a typical installation and determine the amount of food put into the refrigerator, how many times the door is opened, and for how long a period of time the employees are inside the cabinet. This is a very laborious process and, unless very carefully performed, discrepancies are bound to appear in the results.

As the data in the tables are based upon 1 cubic foot content at various temperature differences, so the following method is the usual procedure to determine the usage heat load: The temperature difference is the same value as that used for the heat leakage into this cabinet, while the volume of the cabinet is computed from the inside dimensions. We

next determine under what type of cabinet the box may be classified. A meat market, for instance, may be one in either a small residential neighborhood or it may be a central meat market. There would, of course, be considerable variation in the amount of heat to be removed from the contents of these cabinets. The values given in Figure 264 can only give the load for certain set conditions and it is necessary to understand the individual case.

After the total volume of the box has been calculated, one must determine the load for each cubic foot by referring to the table; if the cabinet appears to be a normal market with a temperature difference of 50°F., the amount of heat to be removed from each cubic foot will be 80 B.T.U. per 24 hours. Multiply this value by the total volume in cubic feet and a fairly accurate estimate of the service load will be obtained. The table gives the heat usage over a period of 24 hours as this time is the established standard. Heat usage = usage B.T.U. × volume in cu. ft.
Using the above example:

Temperature Difference in Degrees Fahrenheit	Use of Refrigerator			
	Florist	Grocery or Normal Market	Market with Heavier Service or Freshly Killed Meats	Restaurant Short Order
40°	40.0	65.0	95.0	120.0
50°	50.0	80.0	120.0	150.0
60°	60.0	95.0	145.0	180.0
70°	70.0	114.0	167.0	210.0
80°	80.0	130.0	190.0	240.0
90°	90.0	146.0	214.0	270.0

Fig. 264. A heat usage table (B.T.U.)
(Courtesy of: Fedders Mfg. Company)

The internal dimensions are = 5 1/6 ft. × 6 1/6 ft. × 9 1/6 ft.

The internal volume $\frac{31}{6} \times \frac{37}{6} \times \frac{55}{6} = \frac{63085}{216} = 292$ cu. ft.

Heat usage under the above conditions = 80 B.T.U. per 24 hrs. for 1 cu. ft.

Heat usage = 292 cu. ft. × 80 B.T.U. per cu. ft. = 23,360 per 24 hrs.

Total Heat Load = Heat leakage + usage = 33,720 + 23,360 = *57,080* B.T.U. per 24 hrs.

The addition of the heat leakage and usage will give the total heat load upon the cabinet for a certain set period of time. This value may be listed either as B.T.U.'s per 24 hours, B.T.U.'s per 1 hour, or as the ice melting equivalent (I.M.E.) for either of these two periods. The conversion factor between B.T.U.'s and ice melting equivalent is 144, meaning that one may divide the B.T.U.'s per hour by 144 and the ice melting equivalent value in pounds will be obtained. This I.M.E. value is another standardized means of comparing capacities; as it always reads in smaller values it is quite popular. This value is used by the Larkin and Frigidaire Corporations.

It may be noted that the accuracy of this type of calculation depends upon the original data and also one should be careful in selecting the tables to be used. The tables in this text have been developed through years of careful investigation and are generally considered satisfactory.

334. ICE MELTING METHOD:

Another way of calculating the total heat load of a cabinet is to use ice as the determining medium. If one were to put an ice bunker in the refrigerator cabinet under investigation in such a manner that the ice would be utilized scientifically,

the number of pounds of ice melting per day to produce satisfactory refrigeration will be a measure of the total heat load on the cabinet. The ice consumed may be measured by collecting the drainage as the ice melts. Two discrepancies that may occur in this method are that the cabinet may require temperatures other than those obtainable by means of ice, and the moisture precipitated out of the air will affect the calculations somewhat. It is also inconvenient in certain cases to put ice into the cabinet to determine the load. Where

Type of Usage	Factor—Btu. per hr. per °F per sq. ft.
Light....	.028
Average..	.042
Heavy...	.056

Fig. 265. Usage Factors—Service Cabinets and Coolers
(Courtesy of: American Society of Refrigerating Engineers)

an installation of automatic refrigeration is to be made in an old ice-cooled box, this method can be used very easily as the ice equipment is already available. The total amount of water drainage does not have to be measured. The most popular way is to measure the drainage for ½-hour periods at four intervals during the 24-hour period.

The heat leakage values in the Larkin and Frigidaire data represent the total heat load. The values are given in pounds of ice melting equivalent per day per 1°F. per 1 square foot of external area. These columns, therefore, base the usage and service upon the area of the cabinet rather than upon the internal volume. Figure 265. These companies do not differ radically from the method previously explained in doing this

because cabinet designs are such that their volume varies almost directly as the area. For example, two cabinets which have the same exterior area very seldom differ in their cubical contents.

334A. COOLING COIL AND CONDENSING UNIT CAPACITIES:

After calculating the heat load, it is necessary to determine the size of cooling coil and condensing unit required to furnish the refrigeration.

Some important features are as follows:

1. The cooling coil removes heat from the cabinet only when the condensing unit is running.
2. The refrigerating unit usually runs from 14 to 20 hours out of each 24 hours. This means that the unit must have a refrigerating capacity in 14 hours of operation equivalent to the total heat load.

The cooling coil's capacity depends upon three conditions:

1. The cabinet temperature
2. The refrigerant temperature
3. The space allowed for the coil

The condensing unit's capacity depends upon:

1. The low-side pressure
2. The condensing medium
3. The kind of refrigerant

It is more important to balance the capacity of the cooling coil to the capacity of the condensing unit than to the heat load of the cabinet. When balancing the capacity of the condensing unit and the cooling coil, all calculations for each must be based on the same low-side pressure. This is because

the cooling coil's capacity increases as the temperature decreases while the condensing unit's capacity decreases as the low-side pressure decreases.

The manufacturers list the capacities of their products in B.T.U.'s or I.M.E. for either 1 hour of operation or 14 hours of operation. Before making a choice of models, it is very important that the above items be considered carefully.

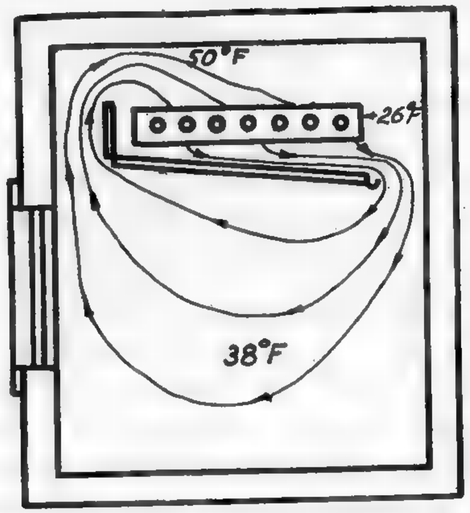


Fig. 266. An illustration showing the circulation of air in an overhead coil refrigerator cabinet

335. BAFFLE DESIGN:

Practically all refrigerator cabinets are now built to be used with mechanical refrigeration. These latter cabinets are specially designed to facilitate cooling of the cabinet with cooling coils. However, old cabinets originally designed for use with ice are sometimes converted into mechanically refrigerated cabinets. This necessitates some minor construction changes in the cabinet to permit the use of coils instead of ice. Also the refrigeration service engineer should know the theory of air circulation in the box, and what is suppoosed

to happen during the operation of the unit. The following deals with the study of efficient baffling and correct air circulation in cabinets.

Baffles are surfaces, or air ducts, which increase the efficiency of the air flow around the coil and throughout the cabinet. They direct the air flow in such a manner that it is speeded up and carried all around the interior of the box, leaving no dead or warm air spots. Figure 266. The colder air coming from the coil is made to flow down the center of the box or adjacent to the wall not provided with windows, while the warmer air is directed through other flues back to the coil. The design must be scientifically proportioned to insure that the air circulation is unrestricted and that there will be no contrary influences to impede the air flow. Any horizontal baffle or coil deck must be insulated because the top surface is in contact with very cold air while the under part of the baffle is in contact with relatively warm air. If it were not insulated, this temperature difference would not be maintained and eddy currents of air would result (small circular flows of air) disturbing the air flow in the cabinet. Baffled coils are always of the natural convection type, and the air flow around the box is due only to the relative weights of the cold air and the warm air (density). The warm air is lighter per cubic foot of volume and, therefore, rises in the box. This natural circulation must never be hindered or the box temperature will not be constant. Baffling the coils tends to promote this natural circulation of the air and to speed it up.

336. COIL BAFFLES FOR A WALK-IN COOLER:

A typical baffle problem is an overhead coil installation in a walk-in cooler. This method is used in a cabinet where sufficient head room remains after the baffle has been installed.

The coil is centrally located in the top of the box and the baffle surrounds it in a certain mathematically proportioned manner. The baffles are divided into two styles called the single baffle and the double baffle. The chutes or flues through which the air is made to flow are proportioned to the size of the box. The easiest way to do this is to consider the sizes of these flues in relation to the floor area of the cabinet. The cold flue or chute must have an area of approxi-

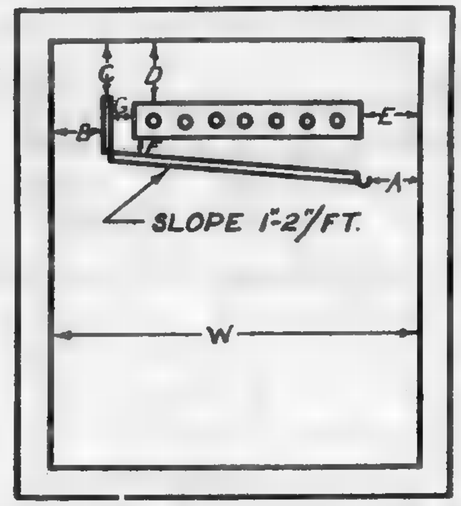


Fig. 267. A single baffle arrangement

A. Cold air flue $=\frac{W}{7}$; B. Warm air flue $=\frac{W}{6}$; C. Same as B; D. C + 1 inch; E. A + 2 to 4 inches; F. 3 to 4 inches; G. 4 to 7 inches

mately one-sixth or one-seventh the area of the floor of the box and the warm air flue must be slightly larger than this to provide for the expansion of the air as it warms up. It is understood that the baffle runs the full length of the cabinet and it always directs the air around the shortest route (the width of the box). Figure 267. The warm air flue is frequently made the same size as the cold air flue although a width of one-sixth the width of the cabinet should be used.

This figure means a slight increase in size of the warm air flue over that of the cold air flue. As the warm air rises in the warm air flue, it must flow over the vertical baffle to reach the coils. The area of the opening at the top of this baffle must therefore be equal to that of the warm air flue.

These overhead coils are used in cabinets which have an exterior height of 9 feet 10 inches. The exact construction of

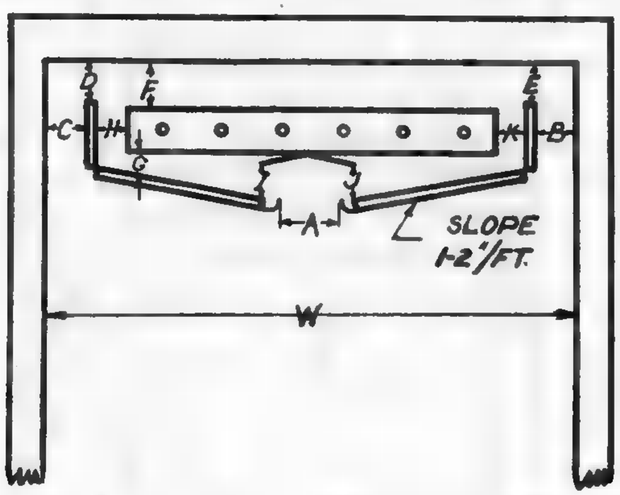


Fig. 268. A double baffle arrangement

A. Cold air flue $= \frac{W}{7}$; B. Same as C warm air flues $= \frac{W}{12}$; D = E = B; F. E + 1 inch; G. 3 to 4 inches; H. Same as K, i.e., 4 to 7 inches; I. Same as J, i.e., $\frac{W}{14}$

the baffle depends upon the width of the cabinet. If the width is less than 7 feet internal dimension, a single baffle may be used, but if the width exceeds this value a double baffle must be used. This double baffle is a construction wherein the cold air is admitted to the center of the box and the warm air rises along the two sides. Figure 268. The same basic rules hold as well for the double flue as for the single

flue types. The total width of the cold air flue must be 1/7 W. and the total of the warm air flues may be 1/6 W. or 1/7 W. This means that each warm air flue is 1/12 W. or 1/14 W. to permit the air that goes up the warm air chute to pass over into the coil chamber. The opening between the vertical baffle and the ceiling of the cabinet must be the same size as the warm air flue, namely 1/12 W. or 1/14 W. The slope of the horizontal baffle should be between 1 and 2 inches per foot of length.

The other dimensions in baffle construction vary somewhat as to the policy followed. It is best to give the baffle as much depth as one conveniently can within the cabinet, but it is recommended that this over-all dimension be not more than 2½ feet. The exact construction of the baffle depends on the type of coil to be mounted within it. If it is a shallow coil of from 6 inches to 8 inches in depth, this coil should have the top of it 1 inch below the top edge of the vertical baffle; this value should be increased as much as possible, still allowing the head room necessary in the cabinet. In other words, a distance of 2 or more inches from the top edge of the coil to the top of the vertical baffle is preferable. If a deep coil is used, i.e., 16 inches to 20 inches deep, it is sometimes necessary to permit the top of the coil to be above the top edge of the vertical baffle. This tends to decrease the efficiency of the baffle construction as it cools the air before it is below the vertical baffle edge, giving it a tendency to flow back through the warm air flue. Under this condition, the coil must be at least two inches from the ceiling of the cabinet. The space between the vertical baffle and the coil proper should not be less than 4 inches or more than 7 inches. If less, the effective area of the coil is decreased. If it is more, air turbulence results, and some of the air is not cooled sufficiently as it goes through the baffle. The coil should be kept 3 inches or more above the horizontal baffle and it should

never be allowed to overhang the flues. That is, in a single baffle construction, the coils should not be allowed to extend over the cold air flue, because this would permit moisture to drip on the contents below. The baffle must be provided with an adequate drain to take care of all condensation from the coil, and it is best made from galvanized iron built to provide its own drainage slant.

337. BAFFLE CONSTRUCTION:

The vertical baffle is usually made of two thicknesses of

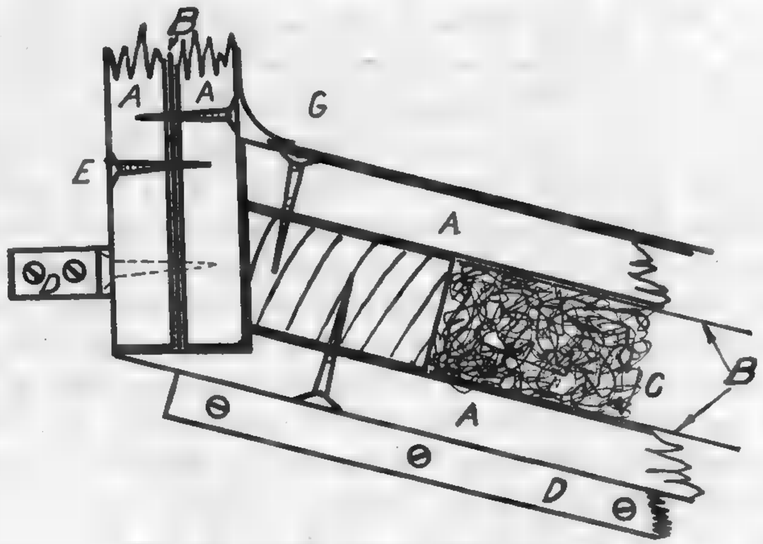


Fig. 269. Baffle details (deck and baffle)
A. ½-inch spruce; B. Sealing paper; C. Insulation; D. Cleats; E. Wood screws; G. Galvanized tin

½-inch spruce lumber constructed with building paper between the two boards giving a total thickness to the vertical baffle of approximately 1 inch. The horizontal baffle must be insulated inasmuch as the top surface of it comes in contact with extremely cold air, whereas the bottom of the baffle comes in contact with relatively warm air. This baffle is also constructed of two layers of spruce wood ½ inch thick, but in addition 1 inch of insulation is mounted between these

two surfaces. During the construction of the baffle, the insulation should be sealed with hydrolene. Figure 269. The top surface of the baffle should be covered with galvanized iron, which must be constructed so the metal will extend partially up to the vertical baffle and also over into the drain trough at the other end of the baffle. Cadmium-plated brass or other rust-proof nails must be used throughout. The vertical baffle is usually fastened permanently into the cabinet by means of angle irons or wood cleats. The horizontal baffle may be fastened at its two ends by the same method, or a preferable method is to mount it as illustrated in Figure 270. That

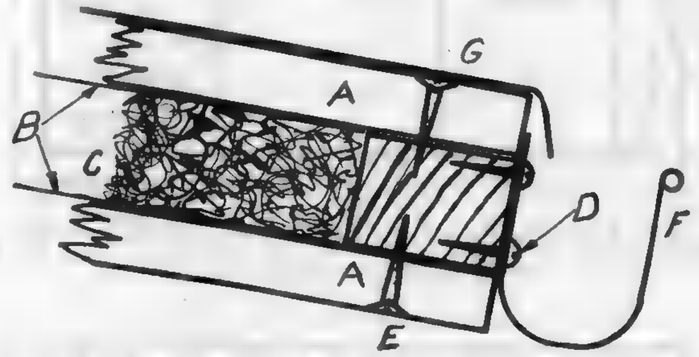


Fig. 270. Baffle trough details
A. ½-inch spruce; B. Sealing paper; C. Insulation; D. Cadmium plated wood screws; E. Brass wood screws; F. Galvanized tin trough; G. Galvanized tin deck covering

part of the horizontal baffle which fastens to the vertical baffle is hinged to it, and the other end is held up by hooks and eyes. This construction permits very easy periodical cleaning of the baffle, and also makes the coil more accessible to the service man. The more modern cabinets, especially those constructed for mechanical refrigeration have the baffles already constructed within them.

338. BAFFLES FOR ODD SIZED COILS:

Many cabinets do not have room to mount overhead coils in

them such as one type of walk-in cooler which is constructed with an exterior height of approximately 7½ feet. This height necessitates some other coil mounting, and two types of mountings are sometimes used. (1) In one method the coil

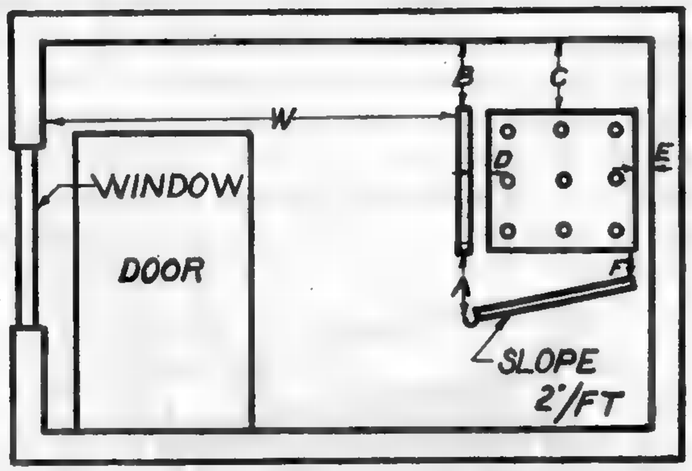


Fig. 271. Corner coil and baffling in a walk-in cooler
W. Width from wall to baffle; A. 1/7 W; B. 1/7 W; C. B + 1; D. 2 inches; E. 2 inches; F. 2 inches

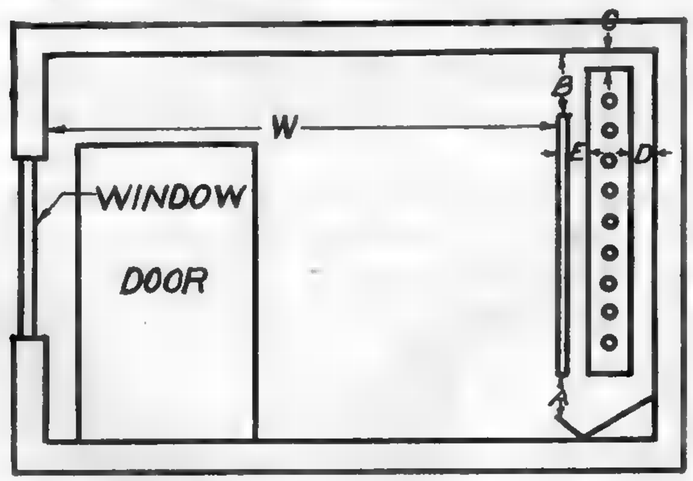


Fig. 272. Wall coil and baffling in a walk-in cooler.
W. Width from wall to baffle; A. 1/7 W; B. 1/7 W; C. 2 inches; D. 2 inches; E. 2 inches

is put in the upper corner of the cabinet as far as possible from the entrance door to the cabinet. Figure 271. (2) The other method uses a wall coil mounted against the wall opposite the windows or the reach-in doors of the cabinet. Figure 272. These coils are baffled, using the same basic values for air flues as the overhead coil. Note that the horizontal baffle in Figure 271 is built to allow a 1-inch space between it and the wall in order to permit a small circulation of air underneath the baffles, thus keeping correct refrigeration in this

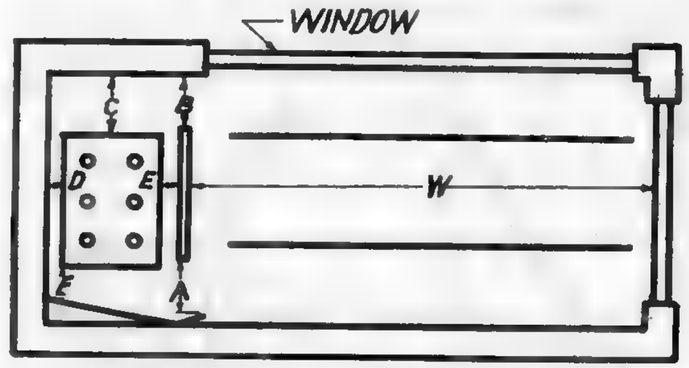


Fig. 273. End bunker baffle arrangement
W. Length from end of counter to baffle; A. $\frac{W}{7}$; B. $\frac{W}{7}$; C. B + 1 inch; D. 2 inches; E. 2 inches; F. 3 inches

space. In this construction the vertical baffle is the one insulated. The construction of the baffles is identical to the construction described in Paragraph 337.

339. DISPLAY COUNTER BUNKERS:

Overhead coil and end bunker display cabinets are baffled for the same reason as in the overhead coil, walk-in cooler. However, the end bunker basic distance (W) is the distance from the baffle of the coil or coils to the extremity of the counter. Figure 273. In the display counter the basic distance (W)

is the intermediate width of the cross section. That is, if the top of the display case is only 1 foot wide and the bottom is 3 feet wide, the basic distance (W) is 2 feet. As in the case of the walk-in cooler, these cabinets frequently come with the baffles already constructed within them. Figure 274. In this case standard baffle designs are installed as have been found to be best in actual tests.

340. GROCERY CABINET BAFFLES:

Grocery cabinet coils are located in the upper center of the

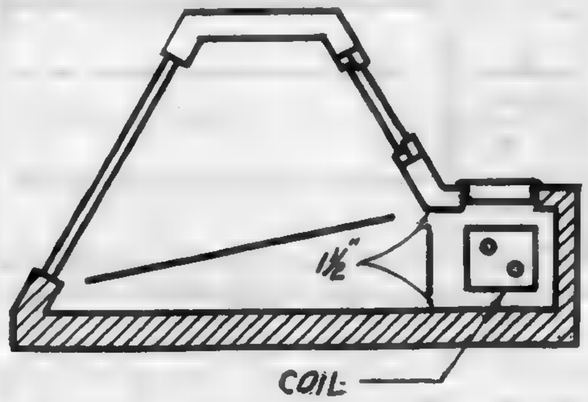


Fig. 274. Display case rear bunker baffle arrangement

cabinet and are baffled with the typical double baffle system. The basic width or W upon which to calculate the various dimensions is the total of the two distances from the vertical baffles to the end walls. That is, if the interior width of a grocery cabinet is 5 feet and the coil space plus the baffle thickness takes up 2½ feet, the baffle dimensions or flues will depend upon the 2½ feet remaining distance or space. The coils cannot be placed as far from both the ceiling and the baffles as in the walk-in coolers; therefore 2 inches is specified as the minimum distance for these spaces.

341. COOLING COIL TYPES AND CAPACITIES:

Many kinds of cooling coils have been used in mechanical refrigeration, but there have been in use two basic types. One type of coil is used to cool the air within the cabinet directly, while the other type of coil is used to cool a liquid (brine) which may be either consumed or used to cool other substances. These are called (1) air-cooling coils, (2) liquid-cooling coils. The air-cooling coils may be further classified as the dry and the flooded type, both of which may be either of the frosting, the defrosting, or the non-frosting type. Also there are forced circulation coils of either the flooded or dry type. The liquid cooling coils may be subdivided into the submerged coil and the tube-within-a-tube coil. In commercial refrigeration certain kinds of coils are tending to become more popular than others. Among these are the dry non-frosting air cooling coils, the forced circulation dry coils, and the submerged flooded or dry coil. See Paragraphs 288 to 295.

342. FLOODED NATURAL CONVECTION AIR-COOLING COIL CAPACITIES:

Previous to the introduction of the thermostatic expansion valve all multiple systems used the flooded air-cooling coil, controlled by a low side float. These coils were most popular during the middle twenties when frosted coils were predominantly used. A frosting coil is that coil which frosts continuously when in use, operating at temperatures always below 32°F.; the machine must be manually shut down periodically to rid the system of frost. These coils run at extremely low temperatures to keep the box cool, which results in an accumulation of frost and ice on them; as this accumulation of frost grows thicker, it decreases the cooling efficiency of the coil tremendously. The capacity of these coils for removing

heat is very high due to the fact that the flooded condition of the coil permits a good transfer of the heat from the fins and tubing to the refrigerant, and the only necessity is to have good air circulation about the fins and tubing. These coils can handle as much as 6 B.T.U.'s per square foot of coil surface per °F. per hour under normal conditions, but they are usually calculated on a basis of 4 B.T.U.'s per square foot of surface per °F. per hour.

The theory involved in the transfer of heat from the air circulating over the coil to the refrigerant is that, as the warm air comes in contact with the coil, the air molecules striking the fins release some of their energy to the fin (transfer the heat to it). This heat in turn travels through the fins, then through the tubing of the coil, and coming in contact with the liquid refrigerant on the inside, tends to boil it. The greatest heat transfer problem in this case is that of the heat in the air to the fin due to the low density of air. After reaching the metal, the heat travels very efficiently and rapidly, but upon reaching the interior surface of the tubing, it again incurs difficulty in reaching the refrigerant in the system due to such things as gas bubbles clinging to the internal surface and an oil film on it.

It is best when calculating or determining the capacity of these coils to rely on the manufacturer's specifications inasmuch as they obtain their heat capacity values from actual experimental investigations. Such things as poor air circulation, frosted fin condition, air turbulence around the coil, and even the amount of moisture in the air will affect the capacity of the coil tremendously. To calculate the external surface area of a coil, care must be taken to consider such things as both surfaces of the fin, the outside surface of the tubing (neglect the area where it comes in contact with the fins) and the external surface of the float chamber. For

example, to find the area of a coil (Figure 275) with 6-inch x 8-inch fins .025-inch thick 10 feet long, having ½-inch fin

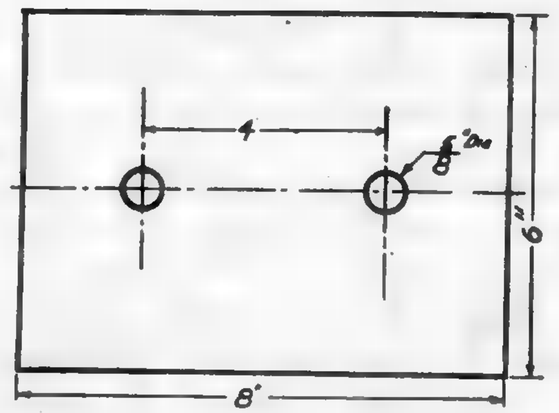


Fig. 275A. Fin specifications for sample problem

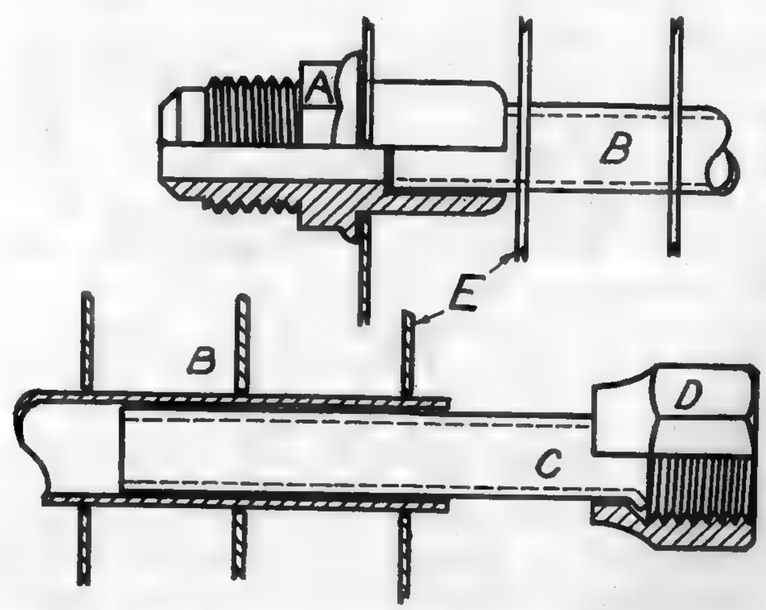


Fig. 275B. An illustration of a dry coil fin construction
A. S.A.E. flared connection; B. Fin tubing; C. Flared tubing; D. Flare nut; E. Fins

spacings and using two 5/8-inch tubes 4 inches apart is as follows:

I. The total number of fins
$10 \times 12 \times 2 = 240$ fins
Fin area = area of each side of the fin minus the area replaced by the tubing

II. Area of one fin $= 8'' \times 6'' \times 2 - \frac{\pi(5/8)^2}{4} \times 2 \times 2 =$
$96 - \frac{80}{64} = 94.75$ sq. in.

III. Total fin area $= 94.75 \times 240 = 22{,}740$ sq. in.

IV. Area of 2 tubes 5/8-inch D; 10 feet long
$2 \times \pi\, 5/8 \times 120 = 15.71 \times 30 = 471.3$ sq. in.

V. The actual tube area is decreased by the thickness of the fins, i.e., the following amount:
Fin contact area $= \pi\, 5/8 \times .025 \times 240 = 15.71 \times .025 \times 240 = 11.78$ sq. in.
Actual tube area $= 471.3 - 11.78 = 459.52$ sq. in.

VI. Tube bend area = length of bend $\times$ circumference
length $= 2''$ radius $\times\, \pi$
circumference $= 5/8'' \times \pi$
Area $= 2'' \times \pi\, 5/8 \times \pi = 10/8 \times 9.87 = 12.2$ sq. in.

VII. Total area $= 22{,}740$
459.52
12.2
$23{,}211.72$ sq. in.
or in sq. ft., $23{,}211.72 \div 144 = 161.2$ sq. ft.

The coil is unable to remove heat from the cabinet when the compressor is not running. Therefore, the heat removing capacity of a coil is calculated on the same running time as that of the compressor. The allowable calculated time for the condensing unit to run and, therefore, the allowable time

for the coil to remove heat from the box during a 24-hour period, varies between 14 and 16 hours in commercial applications.

The more modern flooded coils run on what is called a defrosting cycle, that is, when the condensing unit is running, the temperature of the cooling coil is such that frost accumulates on it, but after the compressor shuts off, the coil must warm up above 32°F. before the condensing unit will start again. The frost accumulation then melts off. This keeps the fin surfaces clear and promotes a more consistent and efficient heat transfer ability of the coil. This is done, however, at a sacrifice to temperature differences between the coil and the air in the cabinet and a greater coil area is needed to compensate for this. The basic calculations are the same, the only change being a smaller temperature difference.

An example of heat transfer ability is as follows: What is the capacity of a coil having an external area of 15 square feet with a coil temperature of 22°F., which means that the refrigerant temperature is about 10°F. to 12°F., if the average box temperature is 38°F. and the air as it enters the bunker is approximately 42°F? Solution: First, it is known that 1 square foot will handle 4 B.T.U.'s per °F. per hour if the condensing unit is running 16 hours. This means that 1 square foot will handle 64 B.T.U.'s per day. The coil temperature is 22°F.; with the air temperature passing over the coil at 42°F., the temperature difference is 20°; if 1° temperature difference will handle 64 B.T.U., 20° will handle 1,280 B.T.U.; then multiply this value by the number of square feet, and we have the total capacity of the coil per day. In the formula form: B.T.U. capacity = K factor $\times$ area $\times$ time $\times$ temperature difference. In this case B.T.U. $= 4 \times 16 \times 15 \times 20 = 19{,}200$ B.T.U. per 24 hours. It is

claimed that the maximum effective distance that the fin should extend from the coil should not exceed 3 inches.

343. NON-FROSTING COILS:

The non-frosting coils have the same heat transfer problem as the one already mentioned with the exception that they operate at a temperature never less than 31°F. This temperature permits only a very slight formation of frost which disappears immediately upon shutting off the compressor. This type of coil uses the thermostatic expansion valve refrigerant control almost exclusively.

344. DRY NATURAL CONVECTION COILS:

Since the introduction of thermostatic expansion valves, dry coils have replaced flooded coils in practically all air-cooling commercial installations. This type of coil has less capacity per square foot than the flooded coil. The heat removing capacity values in B.T.U. per square foot per °F. per hour vary between 2 to 4 with an intermediate value of 2½ B.T.U. per square foot taken as a good value. This is because of the semi-gaseous state of the refrigerant, the tremendous amount of gas bubbles, the oil film on the internal surface of the tubing, and because of the velocities of the refrigerant. The greater the temperature difference, the more rapid the heat transfer. The same method for calculating the heat removing capacity is followed as in Paragraph 342. The policy should be followed of recommending the use of the actual heat removing value as quoted by the manufacturer of the coil. Many types of dry coils are being made at present using the following combinations: copper tubing and aluminum fins, copper tubing and copper fins, and copper fins and aluminum tubing (for ammonia). The fins are usually securely bonded to the tubing; however, some manufacturers

construct the fin to fit the tubing with a fair drive fit. Some manufacturers dip their whole coil in a tinning bath after assembling; others use some mechanical device to attach the fins firmly to the tubing. Figure 276. The fin spacings vary between ½ and 1½ inches. This spacing is a means of varying the capacity of the coil and is also used to compensate for the depth of the coil. The deeper the coil, the greater the fin spacing to minimize air restriction. Coils which have a 6-inch to 8-inch depth may be usually found to have ½-inch spacings and 10-inch and 12-inch depth coils will have 1-inch

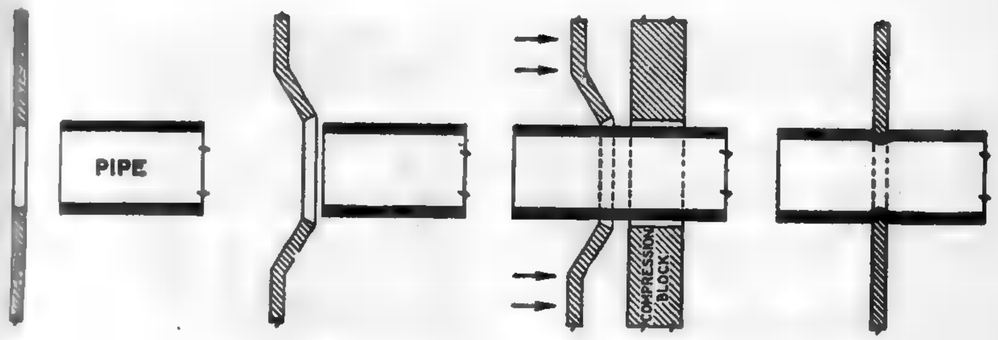


Fig. 276. An illustration showing a mechanical method of bonding a tubing and fin
(Courtesy of: Peerless Ice Machine Company)

spacings, whereas the 18-inch or 20-inch coils will have the 1½-inch spacings. Fin spacings of 1 inch or less are said to decrease air turbulence. The tubing used in the coil is usually ⅝-inch O.D. although ¾-inch O.D. tubing is used in the large coils. Some companies use one continuous piece of tubing for the complete coil, whereas others have all the bends made separately; these are soft soldered, silver soldered, or brazed to the straight lengths. The refrigerant fittings to the coil are usually ½-inch O.D. tubing soldered to the ⅝-inch tubing and then flared with an external nut

mounted on it. Some manufacturers use a ½-inch male flare fitting, soldered to the end fin. The corners of the fins should be braced or reinforced using some method to eliminate bending of them when the coil is being installed. This often consists of right angle strips either clamped or soldered to the fins. Some concerns fit a strip of metal into a slot cut in the corner of each fin. One company (Fedders) uses fins of the stamped fluted construction which enables them to use a coil of the same area as other coils in a smaller overall space. These coils are mounted in the cabinet either by suspending

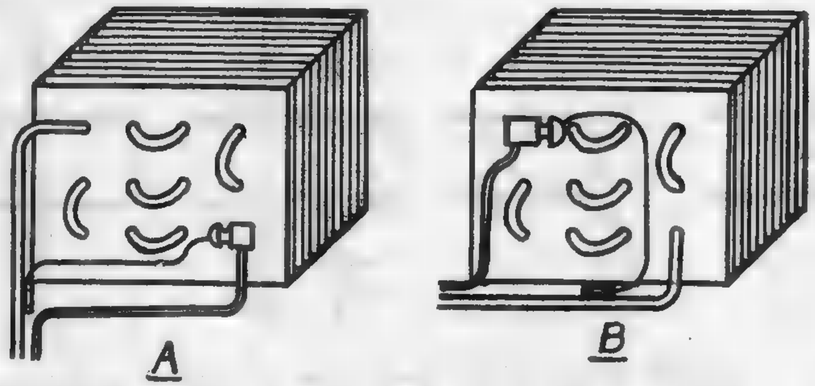


Fig. 277. An illustration showing the two methods of mounting a thermostatic expansion valve on cooling coils
A. Bottom mounted; B. Top mounted

them from the ceiling, by mounting them on pipe, which is fastened to the vertical baffle and the wall of the cabinet, or by mounting them on stands fastened to the horizontal baffle. The thermostatic expansion valve may be mounted to the top of the coil, allowing the refrigerant and oil to flow by gravity to the suction line down to the compressor, or the expansion valve may be connected to the bottom of the coil making the refrigerant pass upward to come to the suction line. The argument for each of these installations is that if the expansion valve is fastened to the upper part of the coil permitting a gravity flow, oil binding will be negligible, but the fins will be coldest at the top in contact with the warm air. If the expansion valve is fastened to the bottom of the coil, the warmer tubing comes in contact with the warmer air first. This theory is in line with water-cooled condenser efficiencies, but the oil return difficulties results in slugging and surging of the refrigerant. Having the refrigerant pass upward as it goes through the coil tends to eliminate frosting down the suction line in most cases. Both methods of installation have their advantages. Figure 277.

Surface in Sq. Ft.			Parallel Paths	Cooling Capacities B.T.U. per Hour		Motor		Fan	
Tube	Fin	Total		15° F. T.D.	25° F. T.D.	H.P.	Speed R.P.M.	Diameter	C.F.M.
2.94	32.39	35	3	2200	4500	1/80	1800	12″	620
5.88	63.0	68	5	4100	7200	1/80	1800	12″	465
7.94	70.06	78	3	5200	9000	1/10	1140	15½″	1200
13.2	116.8	130	5	8300	12300	1/10	1140	15½″	1000
14.7	83.3	98	3	6500	10500	⅛	1140	17″	2020
17.2	145.8	163	5	10000	14000	⅛	1140	17″	1715

Fig. 278. A table of forced circulation cooling coil capacities
(Courtesy of: McCord Radiator & Mfg. Co.)

845. FORCED CIRCULATION AIR-COOLING COILS:

A forced circulation coil is one having an electric fan mounted in conjunction with it in order to produce a flow of air past the coil. Velocities of 400 feet per minute to 2,000 feet per minute are permissible with 1,000 feet per minute being the average value. The coils are finned and the spacing of the fins varies between 3/16-inch and 5/16-inch. Draining facilities for condensation removal must be built into the unit. Figure 226. Sometimes the motors are provided with variable

speeds, but it is more economical to have a one-speed fan. Because of the large amount of air striking the coil per unit of time, the capacity of the coil in B.T.U. per square foot per °F. hour is increased remarkably. The values naturally vary with the air speed and the following table gives approximately an idea as to how this changes. Figure 278. So many variables enter a calculation of this nature that no special values can be given in the text; only the manufacturer's recommendations are to be followed. The table, however, will give one a general idea as to what is the capacity of these coils.

346. LIQUID COOLING COIL CAPACITIES:

Liquid cooling coils, regardless of their type may be calculated for capacity on the basis of a K factor of approximately 15 B.T.U. per square foot per °F. hour. Some of these coils are used to cool a brine solution which, inasmuch as it is a non-freeze solution, does not have any frost accumulation problems. However, many submerged coils use a sweet water bath to provide an ice holdover around the coils and thus maintains a good capacity during peak loads. The capacity of these coils varies tremendously depending upon whether or not they are of the frosting type. As one can understand from the theory of heat transfer, when ice forms around the coil, it necessitates that the heat go through this extra material in order to be removed from the liquid. Ice is a relatively poor conductor of heat and, therefore, the capacity of the coil is decreased. Furthermore, it makes the heat travel through one extra contact surface which reduces efficiency.

347. SPECIAL COIL CAPACITIES:

A considerable variation of cooling coil types may still be found in use; among these are cast metal coils, iron pipe coils, brine spray coils, and intermediate refrigerant coils. The problems incurred with these will be the same as the ones discussed previously. The metal used as the refrigerant carrying device does not have a considerable effect upon the heat transfer capacity of the coil, because its conductivity is relatively so much greater than that contact between the coil and the air that it may be neglected. The capacity of the cast metal coil and the iron pipe coil may be calculated exactly the same as the method described in Paragraph 342.

Some installations use a brine spray. In this system the brine is forced through a pipe extending into the cooling chamber, and this pipe is perforated with a number of fine holes. The brine sprays out of these holes and mixes with the air flowing over the baffle removing the heat. The capacity of these systems is calculated upon the temperature difference between the air in the box and the temperature of the brine. It is safe to assume a high efficiency of heat transfer for brine spray installations.

348. WATER-COOLING LOADS:

The problem of determining the refrigeration load of a water-cooling installation is basically a specific heat and heat leakage problem combination. The water is cooled to temperatures which vary upward from 35°F., and the amount of heat removed from the water to cool it to a predetermined temperature is a simple specific heat problem. The water, being maintained at these low temperatures, results in a heat leakage from the room into the water, and this part involves the heat leakage portion of the installation. The two major factors to be solved in a water-cooling installation are determination of how much water is to be consumed at the tem-

perature difference desired. Figure 279 is a table giving the values of these two variables as recommended by the Temprite Corporation. The temperature of the water should be regulated according to the type of work the consumers are performing, the heavier the work or the warmer the room temperature the warmer the water must be. The amount of water consumed varies extensively in the different applications. By using this table for obtaining the initial values, the exact heat load is easily determined after a very small amount of investigation. For example, item No. 4 in the table points out that for heavy manufacturing the water to be consumed should be kept within 50 to 55°F., and that ¼ gallon per hour per person will be consumed. A production foundry may be classed as heavy manufacturing.

Usage	Final Temp. Required °F.	Total Amount of Water Used and Wasted
1. Office Building—Employees	50	⅛ gallon per hour per person
2. Office Building—Transients	50	½ gallon per hour for each 250 persons per day
3. Light Manufacturing	50 to 55	⅕ gallon per hour per person
4. Heavy Manufacturing	50 to 55	¼ gallon per hour per person
5. Restaurant	45 to 50	1/10 gallon per hour per person
6. Cafeteria	45 to 50	1/12 gallon per hour per person
7. Hotels	50	½ gallon per day per room (14 hr. day)
8. Theaters	50	1 gallon per hour per 75 seats
9. Stores	50	1 gallon per hour per 100 customers per hour
10. Schools	50 to 55	⅛ gallon per hour per student
11. Hospitals	45 to 50	1/12 gallon per day per bed

Note—Total amount of water used and wasted varies with type of installation and kind of service This table will serve as a basis for determining cooler capacity required

Fig. 279. A drinking water cooling table giving the values for various applications
(Courtesy of: Temprite Cooler Corporation)

If a foundry employs 50 men for a period of 8 hours, the water load per day would be 50 × 8 × ¼, which would represent 100 gallons quantity of water to be cooled per 8 hours. If the city water is at a temperature of 75°F. in the pipes it must be cooled 20° to reach the temperature of 55°F. There are 8.34 pounds of water in 1 gallon and the specific heat load would therefore be as follows:

B.T.U. = specific heat × weight × temperature difference, therefore,

Gallons per Hour To Be Circulated per 100 Feet of Pipe to Hold Temperature Rise Within 5° F. Add This Amount to Usage (Fig. 279)

Pipe Size	Temperature Difference Between Room and Circulating Water							
	20°	25°	30°	35°	40°	45°	50°	55°
¼″	4.8	6.3	7.3	3.2	9.7	10.9	12.3	13.6
⅜″	5.5	6.8	8.2	9.6	11.0	12.3	13.7	15.0
½″	6.3	8.0	9.5	11.2	12.7	14.3	16.0	17.6
¾″	6.7	8.4	10.1	11.8	13.5	15.2	16.9	18.6
1″	7.3	9.1	10.9	12.8	14.6	16.5	18.5	20.6
1¼″	8.6	10.4	12.5	14.6	16.6	18.7	20.4	22.1
1½″	9.0	11.2	13.5	15.7	18.0	20.2	22.5	24.7

Fig. 280. Heat loss through insulated cold water pipes
(Courtesy of: Temprite Cooler Corporation)

B.T.U. = 1 × 100 × 8.34 × 20. = 16,680 B.T.U. per 100 gal. water.

The heat leakage for this particular problem is determined by the external area of the insulated parts of the system. One to 3 inches of cork are common thicknesses for water-cooling insulations with ice water thickness insulation being standard at 1½ inches. The heat leakage is calculated identically with that of the heat leakage for cabinets with the exception that this insulation does not have wood on either

side; the cork acts as the only insulation. The example described above deals only with a unit installation.

Many water-cooling installations involve the circulation of the refrigerated water to the various fountains. The heat leakage load in a case of this kind is calculated on the basis of gallons of water per hour to be circulated through the system to maintain satisfactory temperatures.

The table (Figure 280) illustrates the tabular method of computing this load.

349. ICE CREAM COOLING LOAD:

Ice cream is manufactured from milk, solids, fat, sugar, gelatin, and water and, after mixing, the product is cooled to about 27°F. and frozen. It is then cooled rapidly to anywhere from —20°F. and is maintained between 0° to 5°F. if brick, or 5° to 12°F. if bulk, until it is dispensed. The heat values of the various ice creams vary, but the average values are: the specific heat of the mix before freezing is 0.80 and the latent heat at 27°F. is about 90 B.T.U. per pound. The specific heat of the frozen ice cream is 0.45. The weight of the original mix is 9 pounds per gallon; but on freezing, it expands and comes to a density of 5 pounds per gallon, if simply flavored and to 6 pounds per gallon, if it contains fruits or nuts. The heat load of cooling a mix and freezing it is easily calculated from the above.

The next problem is to determine the size of unit to maintain ice cream in its cabinets during the dispensing of it. As mentioned above the ice cream is retailed in two forms—the brick and the bulk. Normally the ice cream cabinet is designed to hold the brick ice cream and the flavored ice creams next to the cooling coil, but many cabinets, especially the recent dry coil models, need separate cooling units for the two types. Vanilla ice cream may be kept at the warmest temperature, while chocolate ice cream must be kept very close to

brick temperatures to keep it from becoming soft. Old cabinets used the low side float refrigerant control and a brine tank exclusively, while at present self-contained models use either the high side float or the automatic expansion valve. Multiple systems use thermostatic expansion valves with the refrigerant tubing soldered to the ice cream compartment sleeves. Metal finished cabinets with 3 inches to 4 inches of slab cork well sealed from moisture are used.

The ice cream is delivered at the correct temperature, and the heat load is, therefore, composed only of leakage and air entering when the covers are removed. The tables (Figures 262 and 263) may be used to calculate the heat leakage for the lack of wood covering. Use the external area and add 20 per cent to take care of the cover openings.

350. REFRIGERANT PROPERTIES:

Before one can understand the operation of the condensing unit as to the compressor capacity and motor capacity, one must have a good understanding of physical properties of refrigerants and how the refrigerant does its work. The refrigerant gas is taken up by the compressor, and a pressure is imposed upon it to convert it to a high pressure, high temperature condition. This action introduces a small amount of heat energy to the refrigerant from the motor and puts it in a condition so that it may be converted from a gas to a liquid again. It is now necessary to determine how large a compressor is needed to produce a certain amount of refrigeration, and how large a motor is needed to drive this compressor. To understand how these values are determined it is necessary to understand the heat behavior of the refrigerant. The refrigerant cycle is simple. The refrigerant is admitted into the cooling coil in the liquid state and at room temperatures. The vaporizing of some of it under the low pressure in the coils cools the remainder of the refrigerant

to the desired refrigerating temperatures, and then as the remainder of the refrigerant evaporates, it removes heat from

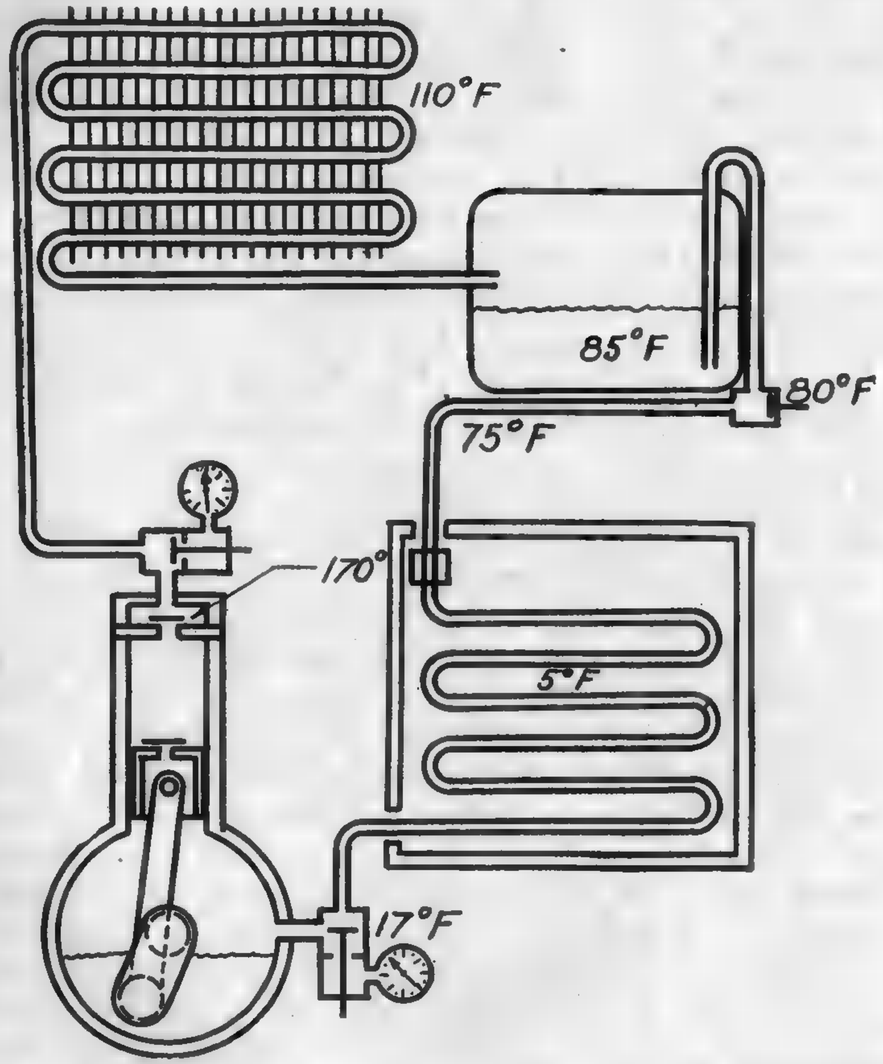


Fig. 281. A refrigerating system showing the approximate temperatures of the refrigerant in the various parts of the system

the cabinet. The total amount of heat absorbed is the *latent heat* of vaporization, while the amount of heat absorbed from

the cabinet and coil is the *effective latent heat.* The refrigerant gas formed on evaporation passes down the suction line; as it does so it remains at the same pressure but it usually warms up somewhat (10°F.). The condition of a gas warming up after it has vaporized is called superheating of the gas. The degree of superheat is the temperature difference between temperature of the gas at the compressor and its temperature corresponding to boiling-point for the corresponding pressure. The compressor then takes the slightly superheated gas and converts it into a high temperature, high pressure gas; the temperature sometimes becomes as high as 150°F. depending upon the refrigerant and conditions. The gas is still in the gaseous state, and the increase in temperature means that the gas is more superheated than ever. This superheated gas passes to the condenser and loses its heat to the air or water and cools down to its vapor pressure temperature. If the vapor pressure temperature is above that of the room, it starts losing some latent heat of evaporation; the quantity of heat it loses determines the amount of the gas that will condense into a liquid. After it has all liquefied, the liquid cools down to room temperatures; then it goes on to the refrigerant control to have its pressure reduced, to be cooled, and to vaporize, thus repeating the cycle. Figure 281.

To study the behavior of this refrigerant more accurately, we will base our discussions of it upon 1 pound of the refrigerant regardless of its state. The discussion will deal only with the pure refrigerant, neglecting the effect of lubricating oils and other influences. Figure 282 shows a chart which illustrates the behavior of one pound of refrigerant in a refrigerating machine. The horizontal scale shows the amount of heat present in 1 pound of refrigerant at all times and under all conditions; whereas the vertical scale shows the pressure imposed upon it. Using this chart as a basis for

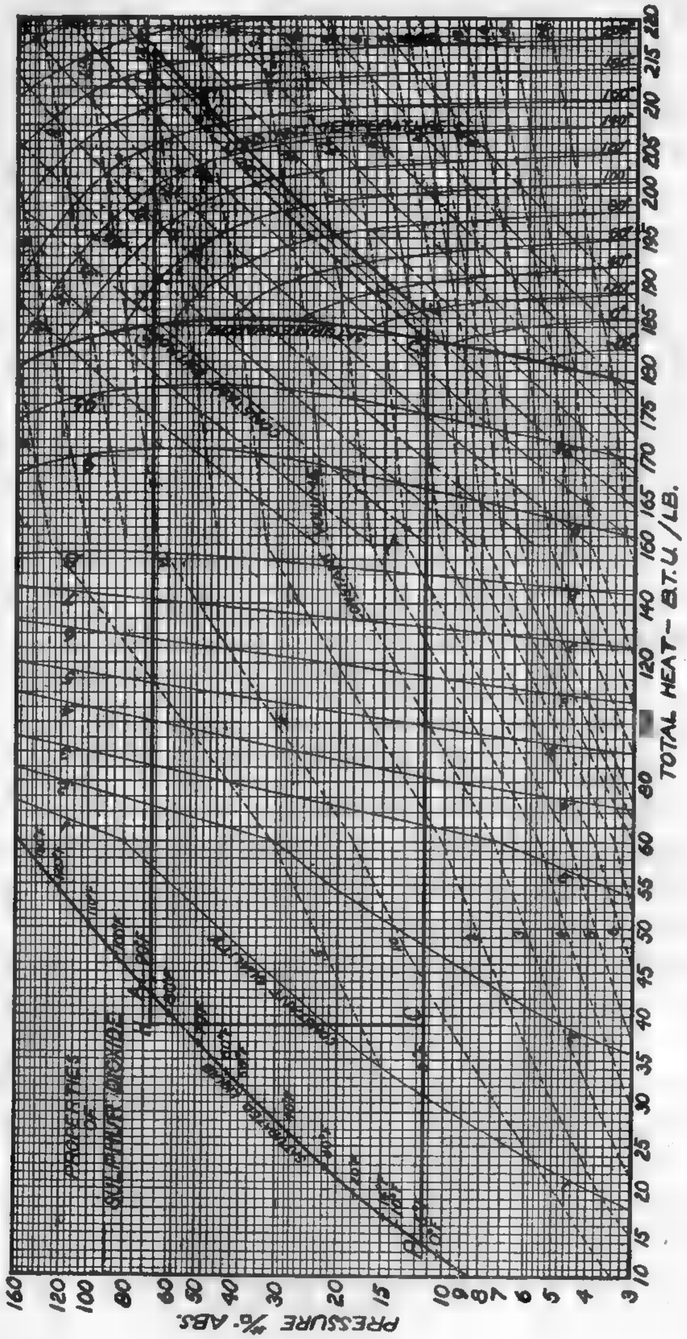


Fig. 282. A pressure-heat diagram of sulphur dioxide. The saturated liquid curve represents the heat in the liquid at the various pressures before it will start vaporizing. The saturated vapor curve represents the division between the super heated gas and where the gas starts condensing into a liquid
(Courtesy of: American Society of Refrigeration Engineers)

discussion, one will note that as the refrigerant vaporizes at a constant pressure it passes horizontally from B to D. This line indicates the vaporization of the refrigerant from a liquid into a gas in the cooling coil. The distance D to E represents the heating of this gas into a superheated condition as it passes down the suction line. Note that a few B.T.U.'s of heat have been added. Point E is the condition the gas is in when it is taken by the compressor and compressed. Note how the pressure increases rapidly and how a few B.T.U.'s of heat are added to the gas. The gas is now considerably superheated. Point F represents the condition of the gas as it leaves the exhaust valve of the compressor. The distance between F and G is the cooling of this superheated gas down to the point where it starts to condense. The line G to A represents the condensation of the refrigerant in the condenser from a gas into a liquid. Point A represents the amount of heat in the liquid and the pressure imposed on the liquid as it forms in the condenser. From A to H is the loss of heat from the liquid as it passes up the liquid line to the refrigerant control. Point H to C represents the throttling of the liquid upon passing through the refrigerant control, and the cycle is ready to be repeated for the one pound of refrigerant. Note that the distance C to D does not represent the total *latent heat* of the liquid at the low side pressure condition. This means that sulphur dioxide which has a latent heat of 169.38 B.T.U. per pound at 5°F. will not remove all of that heat from the cooling coil because some of it (approximately 28.3 B.T.U.) is used to cool down the liquid refrigerant to the 5°F. temperature before it can vaporize. The 141 B.T.U. remaining is called the *effective latent heat* or the *effective refrigerating capacity.*

851. LATENT HEAT:

The valve of the latent heat of the refrigerant when vapor-

izing and when condensing in a refrigerating machine is different. At the lower pressure (vaporizing), as one may see from Figure 282, the total latent heat to be added to the liquid to vaporize it is more than that needed to be subtracted to condense it into a liquid at the higher pressure. The explanation for this is that the liquid, when formed, is at a higher temperature than the liquid at the vaporizing pressure. This difference is represented by the specific heat of the refrigerant multiplied by the °F. temperature difference for the two conditions. The actual cooling or amount of heat removed is not equal to the latent heat of the refrigerant at the lower pressure but is somewhat less, and the actual heat removing ability is called the *effective latent heat*. The effective latent heat of the refrigerant, when vaporizing, is the total latent heat at the low pressure minus the difference in the heat content of the two liquids at the high pressure and low pressure. This is because the high pressure liquid, when throttled in the refrigerant control, must be cooled down to the low pressure temperature liquid before it can vaporize and remove heat from the surrounding substances. Part of the liquid vaporizes in order to cool its own liquid to the lower temperature. The effective latent heat is an average value because the low side pressure varies somewhat during the operation of the system, due to the oil in the system, and because ideal conditions cannot be maintained. For methyl chloride the latent heat of vaporization at 5°F. is 179 B.T.U. per pound but its actual heat absorbing ability is only approximately 151 B.T.U. per pound. See Figure 319.

352. SATURATED GAS:

A saturated gas is a gas in such a condition that if a little heat were removed from it, some of the gas would condense.

An example of a saturated gas is illustrated in a refrigerant cylinder half full of liquid refrigerant. The gas in this space is saturated gas. This leads to another definition that saturated gas is a substance in a gaseous form in the presence of some of its own liquid. When the refrigerant vaporizes in the cooling unit, it is a saturated gas at first; but as this gas passes down the suction line to the compressor, it usually becomes warmer by 5°F. to 15°F. This additional heat and increase in temperature is called superheating the gas; that is, it is raising the gas above a saturated condition, for this pressure and the gas will now obey Charles's and Boyle's Laws.

353. SUPERHEATED GAS:

A superheated gas is gas in such a condition that if some heat were removed from it, the volume of the gas would decrease, but there would be no condensation. The gas that the compressor handles is always superheated unless a condition arises wherein liquid refrigerant is admitted to the crankcase. The low pressure superheated gas, when it enters the compressor, is compressed; the energy, put into it by the compressor, increases the temperature and pressure on this gas tremendously. The degree of superheat is increased. This superheating of the gas lowers a machine's efficiency and the less the superheating, the more efficient the machine will be. The heat added to the gas is the mechanical energy of the compressor being converted into heat energy; by knowing how much heat has been added, one may calculate the size of the motor necessary to drive the compressor. See Paragraph 358 for problems illustrating this principle.

354. SPECIFIC HEAT:

The specific heat of a substance is the amount of heat neces-

sary to raise the temperature of 1 pound of that substance 1°F. Substances may exist in three different states (solid, liquid, and gas). Every substance has three different values for its specific heat, depending upon whether it is a solid, a liquid, or a gas. The specific heat of the gas may be found subdivided into the specific heat under a constant pressure, or the specific heat under a constant volume. The specific heat of a gas under constant pressure is more than that of the same gas under constant volume, because when a gas is heated with a constant pressure being maintained upon it, the gas expands and does external work; this external work naturally necessitates an additional quantity of heat. When a compressor compresses 1 pound of the refrigerant gas, it does not add heat to it under a constant pressure or constant temperature condition. This state of affairs in the compressor is called adiabatic compression, meaning that no heat has been removed from the gas as it was compressed. Actually a refrigeration compressor operates almost adiabatically because the compression takes place so rapidly. The specific heat of liquid refrigerants varies considerably, depending upon the pressure imposed upon them. One must determine the pressure to which the liquid refrigerant is subjected in the condenser, after it has condensed, to calculate how much heat must be removed from 1 pound of the liquid to further cool it to room temperature. After the refrigerant passes through the throttling valve, it is subjected to a new pressure which is lower. One must now determine the specific heat of liquid under this new pressure to find out how much heat must be removed from it to cool it down to the vaporizing temperature. If the liquid refrigerant is cooled before it is admitted through the throttling valve, it will increase the efficiency of the system. This device is incorporated in many water coolers and it is the reason back of running the liquid

and suction lines together. They are sometimes soldered together. These devices are called heat exchangers.

455. COMPRESSOR CAPACITIES:

As mentioned previously the compressor is the heart of the machine; it is the mechanism used to impart energy to the refrigerant to enable continuous refrigeration. The compressor is the means whereby the mechanical energy produced in the electric motor is converted into heat energy in the refrigerating machine. The most efficient construction possible is to have a compressor built large enough just to handle the amount of refrigeration necessary. If the compressor is too large, energy is lost in excess friction, starting energies, etc.; whereas, if the compressor is too small, it will not be able to produce the amount of refrigeration required. Basically, the compressor must remove the gas sufficiently fast from the cooling coil to enable the refrigerant to vaporize at a low pressure. To do this it must remove the refrigerant vapor as fast as heat goes into the cooling coil and forms it. The method of determining the compressor's size may be simply stated as follows: A cooling coil is designed to remove a certain amount of heat over a 16-hour running period. This amount being dependent upon the factors described in previous paragraphs. Let us say that the effective heat removing ability of the refrigerant is 140 B.T.U. per pound, meaning that as each pound of refrigerant vaporizes in the cooling coil it picks up exactly 140 B.T.U. of heat from the coil itself. To remove this amount of heat from the coil, the compressor must handle all the gas formed. Refrigerant tables give us values called specific volumes. Paragraph 452. These specific volume values mean that at that certain pressure 1 pound of the refrigerant vaporizing will form a certain number of cubic feet of gas. For example, 1

pound of sulphur dioxide vaporizing at 0 pound per square inch pressure forms 5.2 cubic feet of gas in 10 minutes. The compressor, in order to remove the same amount of heat from the cooling coil during the period that the cooling coil removes its heat from the cabinet, must remove the 5.2 cubic feet of gas in 10 minutes; the compressor must remove this gas in the same length of time. How large a compressor is needed to do this depends upon the following compressor factors: the volume pumped per stroke of the piston, which is dependent upon the bore, stroke, number of cylinders, the speed of the compressor in revolutions per minute, and the volumetric efficiency. As the crankshaft of the compressor completes one revolution, the piston reaches the lower dead center of its travel, and the low pressure gas fills up the space between the top of the piston and the head of the cylinder. Then as the crankshaft completes its revolution, the piston compresses this gas and pushes it through the exhaust valve into the high pressure side of the system. The volume handled in each case is the volume displaced by the piston as it moves from upper dead center to lower dead center. This volume may be calculated by the following formula.

$$V = \frac{\pi \times D^2 \times S \times N \times R}{4}$$

V = Volume in cu. in.
S = length of stroke in in.
D = Diameter of cylinder
N = number of cylinders
R = R.P.M.

This formula simply calculates the area of the piston head and then multiplies it by the length of the stroke producing the displacement volume in cubic inches. Now, if this is multiplied by the number of cylinders used, and the revolutions per minute of the compressor, the total volume in cubic inches pumped per minute will be obtained.

Illustration problem:

Calculate the bore and stroke of a single cylinder compressor which, operating at 300 R.P.M., will compress the refrigerant gas formed by vaporizing 1 pound of sulphur dioxide at 0 pound per square inch pressure (5.2 cubic feet).

Solution:

$$V = 5.2 \text{ cu. ft.} = 5.2 \times 1728 \text{ cu. in. per cu. ft.}$$

$$= \frac{8985.6}{10} \text{ cu. in.}$$

$$\text{Volume pumped per min.} = \frac{8985.6}{10} = 898.56 \text{ cu. in.}$$

Using the formula

$$V = \frac{D^2 \times S \times N \times R}{4} = 898.56 \text{ cu. in.}$$

Compressors are usually designed with a bore equal to the stroke. So in formula becomes:

$$V = \frac{\pi D^3 \times N \times R}{4} = 898.56 \text{ cu. in.}$$

$$D^3 = \frac{898.56 \times 4}{300 \times 1 \times \pi} = 3.81 \text{ cu. in.}$$

$$D = S = 1.56 \text{ in. approximately.}$$

However, this value obtained is the theoretical amount of gas pumped by the compressor. Actually, the amount is much less and the actual amount depends upon the volumetric efficiency of the compressor. See next paragraph.

356. VOLUMETRIC EFFICIENCY:

If a refrigerating unit is maintaining a 90 pounds per square inch head pressure and a 0 pound per square inch low side pressure, the following things are evident: when the piston is on its upward stroke, it compresses this 0 pound per square

inch gas until the pressure of the gas in the cylinder reaches 90 pounds per square inch. When this pressure is reached, the gas should start passing through the exhaust valve into the condenser. However, in addition to reaching this high side pressure, it must overcome the exhaust valve spring tension or weight. This means an additional increase in pressure. Further, after the piston reaches upper dead center, there is still a little volume of the gas between it and the exhaust valve. This is necessary because if no clearance were left between the two, when the piston came up it would pound against the cylinder head. This little volume of gas is under a high pressure of 90 pounds per square inch or more, and as the compressor piston goes down to receive a new charge of gas, this high pressure gas expands and partially fills the cylinder chamber. This decreases the amount of gas that may come into this chamber from the low pressure side of the system. Also at speeds of 300 revolutions per minute or more, the piston is traveling so fast that the inertia or the inability of the gas to move fast enough prevents it from filling the cylinder chamber completely and losses are encountered in this manner. One can see from this that the higher the speed of the compressor, the less gas will be pumped per stroke. Other losses, such as the leaking of the gas past the piston and rings back into the crankcase, etc., also explain why compressors cannot pump the amount of gas as calculated by using the bore and stroke formula. The term, *volumetric efficiency, is defined as the ratio between the volume actually pumped per revolution divided by the volume calculated from the bore and stroke and R.P.M.* For small compressors used in domestic refrigeration, having bores and strokes of 1½ inch or thereabouts, the volumetric efficiency varies from between 40 per cent and 75 per cent with 60 per cent being a fair medium value. The larger commercial compressors depending upon their size and speed have volumetric

efficiencies between 50 per cent and 80 per cent with 70 per cent being a fair value. The 60 per cent to 65 per cent volumetric efficiency should be used if the unit is air-cooled. If the compressor explained in Paragraph 355 has a volumetric efficiency of 60 per cent the size of the compressor would be increased as follows:

As calculated in Paragraph 355.

$D^3 = 3.81$

$$D^3 \text{ corrected} = \frac{3.81}{.60} = 6.35 \text{ cu. in.}$$

D corrected = 1.85 in.

or a bore and stroke of

1⅞ in. × 1⅞ in. would be required

Note that the correction for volumetric efficiency was made on the displacement volume of the cylinder and not on the calculated bore and stroke. The volumetric efficiency of a compressor is very dependent upon the relative difference between the low side pressure and the high side pressure of the machine. For instance, in a sulphur dioxide machine when being used for domestic purposes, the compressor will be much more efficient than if it were converted over into an ice cream system, because the decrease in low side pressure from 5 inches vacuum down to 15 inches vacuum with the same head pressure, reduces the actual pumping capacity of the compressor tremendously. The low pressure gas is expanded so that when the cylinder is filled at the low side pressure, only a very small amount, by weight, is represented.

357. MOTOR SIZES (MEAN EFFECTIVE PRESSURE METHOD):

The size of an electric motor necessary to drive a compressor in a refrigerating machine may be calculated on two basically different plans. (1) The H.P. of the motor may be calculated

by determining the H.P. put into the compressor. This H.P. is based upon the speed of the compressor and the mean effective pressure (M.E.P.) of the gas in the compressor. (2) The size of the motor may be determined by using the amount of heat added to the gas in the compressor as the energy taken out of the motor.

The M.E.P. of the gas is the medium pressure bearing down upon the piston head, and it is the pressure to be overcome by the electric motor when driving the compressor. The M.E.P. is determined by a formula which uses as the basic variables the low side pressure, the high side pressure, and the ratio of the specific heat of constant pressure to the specific heat of constant volume $\frac{C_p}{C_v}$ for the kind of refrigerant. This formula is as follows:

$$\text{M.E.P.} = P_1 \times \frac{K}{K\text{-}1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{K-1}{K}} - 1\right]$$

P_1 = Absolute suction pressure in pounds per sq. in.
P_2 = Absolute condenser pressure in pounds per sq. in.
$K = \frac{C_p}{C_v}$ (1.20 for methyl chloride) See Figure 319.

This value when multiplied by the area of the piston, by the length of the stroke, and by the R.P.M. will give the foot-pounds per minute needed to drive the compressor.

$$\text{Ft.-lb. per min.} = \text{M.E.P.} \times \frac{\pi D^2}{4} \times S \times N \times R$$

Convert the foot-pound per min. into H.P. by dividing by 33,000.

$$\text{H.P.} = \frac{\text{ft. \#/min.}}{33{,}000}$$

The M.E.P. may be determined from the above or may be determined by obtaining the indicator card of the compressor being studied. Engineers handbooks set forth the methods of using and obtaining indicator cards.

For example: if the indicator card shows a M.E.P. of 30 pounds per square inch the indicated H.P. necessary to drive a 1 cylinder compressor with a 2-inch bore and a 2-inch stroke and running at 200 R.P.M. would be as follows:

$$\text{H.P.} = \frac{30 \times 2 \times 200 \times \pi \times 2^2}{12 \times 3300 \times 4}$$

$$= \frac{r \times 8 \times \pi}{37000 \times 4} = \frac{10 \times \pi}{330} = \frac{3.1.416}{330} = .0952$$

or 1/10 H.P.

This is the theoretical H.P. and neglects friction, oil pumping, starting load, drive losses, etc. Up to a 1 ton machine one should double this H.P., i.e., ¼ H.P. calculated will need a ½ H.P. motor. Up to 5 tons this ratio gradually tapers off to adding 30 per cent at 5 tons capacity to take into consideration the above losses. The reason for the decrease is that some of the losses remain constant, while others do not increase as rapidly in proportion to the increase in the size of the unit.

358. MOTOR SIZE (HEAT INPUT METHOD):

From the pressure heat charts, one can readily determine the amount of heat (B.T.U.) added to a gas when compressed by the compressor. Referring to the sulphur dioxide pressure heat chart (Figure 282), one will notice that approximately 242 B.T.U. are added to the 1 pound of gas if the low side pressure is 0 pound per square inch and the high side pressure is 51.75 pounds per square inch gauge.

It is known that 2545.7 B.T.U. per hour is equal to 1 H.P. and is also equal to 746 watts.

For example:

Calculate the H.P. required to drive the above compressor.

24.2 B.T.U. are added per pound.

1 pound of refrigerant is compressed in 10 min.

$$\text{The B.T.U. rate per hour} = \frac{24.2}{10} \times 60 = 145.2 \text{ B.T.U. per hour.}$$

$$\text{The H.P. required (B.T.U. method)} = \frac{145.2}{2546} = .057 \text{ H.P.}$$

This is the mechanical equivalent of the heat energy put into the gas; if the compressor friction were 0 and the belt drive were 100 per cent efficient, this would be the size of the motor necessary to drive the compressor. However, one must add about 50 per cent to this value to allow for compressor friction and belt efficiency. This would require about 1/12 H.P. However, the starting requirements demand a motor torque of 50 per cent to 100 per cent greater than the running torque. This will bring the size of the motor up to approximately ⅛ to 1/6 H.P.

359. MOTOR DRIVES:

Three means have been used for connecting the electric motor to the refrigerating compressor. In their order of popularity, these are: the belt drive, the direct drive, and the gear drive. The belt drive may be further subdivided into a single V-belt, single flat belt, and multiple V-belt. The multiple V-belt is the most popular drive at the present time, and from two to ten belts are used as the driving medium with two to four belts being the most prevalent. This method of drive, when correctly adjusted, is between 95 per cent and 97 per cent efficient. This type of drive will maintain its efficiency over a greater range of belt tautness than any other drive; because of this and because the belt will not jump, it is the most generally used. Direct drives are universal in hermetic units regardless of their size and have been used frequently in small conventional units. The drive is very efficient, but such factors as the difficulty of alignment, the excess torque load due to seal pressure, and because of the drop in volumetric efficiency of the compressor at the higher motor speeds, most companies prefer the slower belt-driven unit. Several manufacturers are now producing directly driven compressors and have very successfully overcome many of its natural drawbacks. A gear-driven compressor is a very positive means of drive, eliminating such troubles as belt slippage and wear, but the increase in cost due to gear lubrication and casing, and the matter of gear noises have almost completely eliminated this type of machine from the refrigerating market. On farms and other places, where electricity is not available, commercial units are typically driven by means of a gasoline engine. This gasoline engine drive is usually connected by means of V-belts to the compressor, but they are also being directly connected.

360. MOTOR EFFICIENCY:

Theoretically, an electric motor should produce 1 H.P. of mechanical energy for every 746 watts of electrical energy put into it, that is, a 1 H.P. electric motor on a 110 volt circuit should only consume 6.8 amperes. This situation, however, is not encountered because of bearing friction, magnetic eddies, magnetic air gaps, and power factor. The efficiency of the motor is the mechanical energy delivered at the motor shaft divided by the power input to the motor. For small domestic motors of approximately 1/6 H.P., the

efficiency of the motor is only 40 per cent to 60 per cent, and for 1 H.P. to 2 H.P. the motor efficiency increases to from 75 per cent to 80 per cent. As the size of the motor increases, the efficiency increases; this is due to the fact that friction losses and air gap losses remain practically constant regardless of the size of the motor. Motors with an efficiency of 95 per cent to 98 per cent are common in the large sizes.

361. MOTOR OVERLOADS:

In the conventional system in addition to maintaining compressor speed against certain resisting factors, the motor must take the compressor from an idle position and bring it up to its rated speed. The energy necessary for this is greater than that necessary to maintain the compressor at this speed. This load is called the starting load, and is anywhere from 50 per cent to 100 per cent larger than the load imposed upon the motor when running. This load is due to the acceleration force imposed by the moving parts of the compressor which is termed inertia; that is, all bodies resist a tendency to change their speed of motion, and this resistance depends upon the mass and the rapidity of this change of speed. A motor which consumes 4 amperes when running normally will consume as much as 7 and 8 amperes when starting. In other words, a 1/3 H.P. motor when starting up sometimes will develop as much as 2/3 of a H.P. in order to overcome the compressor inertia and bring the compressor to its speed. This is a 100 per cent overload and must not be carried for any length of time.

362. CONDENSER CAPACITIES:

The calculation of the capacity of a condenser is similar in many ways to the problem of computing the capacity of a cooling coil. The condenser must dissipate the heat from the

gas fast enough so that just as much gas condenses in the condenser as is being pumped into the condenser by the compressor in a given unit of time. When this condition is reached the head pressure will build up until the temperature rises to the point where the heat dissipated will equal the heat put into the condenser. The problem of computing the capacity of the condenser varies according to the type of condenser being used. We may divide condensers under the following headings:

1. Air cooled:
   - *a*) Plain tubing
   - *b*) Finned tubing
   - *c*) Natural convection
2. Water-cooled:
   - *a*) Liquid receiver type
   - *b*) Tube-within-a-tube type

363. AIR-COOLED CONDENSER CAPACITIES:

The capacity of an air-cooled condenser may be calculated from one of two basic values. Some prefer using the total external area of the condenser to compute its heat dissipating ability, while others base computation upon what is called the frontal area of the condenser. Using the total external area of the condenser, the capacity of the condenser for dissipating heat depends upon the following variables: (1) external area, (2) temperature difference, (3) time, (4) air velocity.

Using these values the capacity of an air-cooled condenser varies between 2.5 B.T.U. per square foot per °F. per hour and 4 B.T.U. per square foot per degree temperature difference. The effect of air velocity is to increase the condenser's capacity with an increase in air speed. The fans used to do this work are generally mounted on the motor shaft, and

drive the air through the condenser at speeds between 400 to 1,000 feet per minute. When a fan of 400 feet per minute is used, the 2.5 B.T.U. per square foot per °F. per hour value will be found satisfactory, and this value will increase up to approximately 4 B.T.U. with a 1,000 feet per minute air velocity. The calculation of the area of a condenser is identical to that for a finned coil (Paragraph 342). A single tube condenser has a total area of approximately 20 times its frontal area. For example: If a condenser has 10 square feet of surface with an air velocity of 400 feet per minute, what must be the refrigerant temperature to dissipate 5,000 B.T.U. per hour if the room temperature is 75°F.?

$10 \times 2.5 \times$ temperature diff. $= 5{,}000$

$25 \times$ temperature diff. $= 5{,}000$

Temperature diff. $= 200°F.$

Refrigerant temperature $= 200 + 75 = 275°F.$

The same problem using a 50 square foot condenser.

$50 \times 2.5 \times$ temperature diff. $= 5{,}000$

$125 \times$ temperature diff. $= 5{,}000$

Temperature diff. $= 40°F.$

Therefore, the refrigerant temperature $= 115°F.$

The same problem using a 75 sq. ft. condenser.

$75 \times 2.5 \times$ temperature diff. $= 5{,}000$

$$\text{Temperature diff.} = \frac{5{,}000}{187.5}$$

Temperature diff. $= 26.7°F.$

Therefore, the refrigerant temperature $= 101.7°F.$

The heat to be removed by the condenser for each pound of gas is the heat content of the gas, when it leaves the compressor, minus the heat of the liquid at the condensing pressure.

Example:

In the illustration (Figure 282) the gas has a heat content of 213.5 B.T.U. when it leaves the condenser, and the heat to be removed by the condenser is this value minus 42.5 B.T.U., the heat of the liquid at 86°F. (temperature at condensing pressure).

$213.5 - 42.5 = 171.0$ B.T.U. per pound of refrigerant condensed.

From an understanding of the refrigeration cycle, one may realize that if a condenser is under capacity, the compressor head pressure will rise in proportion in order to dissipate the required amount of heat; therefore one may put condensers of various sizes on the same compressor. If too small a condenser is used, a decrease in compressor efficiency, an increase in motor load, and a decrease in the life of the unit will result. The examples above illustrate this principle.

When the capacity of the condenser is based upon frontal area, it is claimed that the air being blown through the condenser is removing heat only from that surface which it strikes directly, and that the turbulent flow against the rear surfaces makes the heat removal from these surfaces negligible. The capacity per square foot of frontal area naturally is greater than the value stated above, and is between 6 to 10 B.T.U. per square foot per °F. per hour, depending upon the air speed. For air-cooling one should use the dry bulb temperature of the room.

Natural convection condensers are becoming popular in the domestic refrigeration field. Several manufacturers are producing units which utilize a motor and compressor design inside a steel dome. This necessitates a separate motor to force air through the condenser. To eliminate this motor, some companies are building large natural convection condensers mounted on the back of the cabinet. The size of these condensers is sufficient to permit cooling without the need of forced draft. The heat removing ability of these is between 1 to 2 B.T.U. per square foot per °F. per hour.

364. WATER-COOLED CONDENSER CAPACITIES:

The capacity of a water-cooled condenser is very high due to better heat contact between the cooling medium and the refrigerant for either the liquid receiver type or tube-within-a-tube type. The heat removing capacity of these varies between 30 and 50 B.T.U. per square foot per °F. per hour in the smaller machines. For machines of a ton capacity or more, this value may be increased up to 90 B.T.U. per square foot per °F. per hour. In addition to this heat removal, one must also calculate the air-cooling surface of the condenser, such as the external area of the liquid receiver, or the external area of the refrigerant tubing in the tube-within-a-tube type, to reach the correct capacity. In the water-cooled systems, the velocity of the water must be taken into consideration because with an increase of water flow or velocity, the efficiency is increased. The method of determining the temperature difference between the cooling medium and the refrigerant is to use, as the refrigerant temperature, the saturation temperature of the refrigerant according to the head pressure obtained. Water temperatures should be taken as the average between the water-in and water-out temperature. For example:

A shell type water-cooled condenser has to remove 5,000 B.T.U. per hour. How much tubing 3/8 O.D. must be put into the receiver to remove this heat if the water supply is 70°F.? The outlet water is 80°F. How many gallons of water per hour must be circulated? Consider the refrigerant temperature at 100°F. Assume the heat removing capacity of the condenser to be 40 B.T.U. per square foot per °F. per hour.

Tube area=

Condenser capacity = area (sq. ft.) × temp. diff. °F. × B.T.U. rate × time.

$$5{,}000 = \frac{\pi\ 3/8 \times \text{length (in.)}}{144} \times 25 \times 40 \times 1$$

$$\frac{5{,}000}{\blacksquare \times 40} = \frac{\pi\ 3/8 \times \text{length (in.)}}{144} \quad \text{or} \quad \frac{5{,}000 \times 144}{25 \times 40} = \pi 3/8 \times \text{length}$$

$$\text{or length} = \frac{5000 \times 144}{25 \times 40 \times \pi\ 3/8} = \frac{720}{\pi 3/8} = \frac{720}{3.1416 \times .375}$$

$$\frac{1920}{3.1416} = 611 \text{ in.}$$

$$= 51 \text{ ft. approximately}$$

The amount of water circulated =

sq. ft. × wt. × temperature difference = B.T.U.

1 × wt. × 10 = 5000

1 gal. of water weighs 8 1/3 lbs.

$$\text{wt.} = 500 \text{ lbs.} = \frac{500}{8\ 1/3} = 60 \text{ gal. of water per hr.}$$

365. REFRIGERANT LINES:

The liquid and suction lines on refrigerating machines must be of sufficient size to handle the amount of the liquid or the gas required. The method of calculating the capacities of these lines is to determine the maximum velocity allowed in the line and then, knowing the amount of gas or liquid to be handled, the internal cross-section of the line may be easily calculated.

366. REFRIGERANT LINE CAPACITIES (LIQUID):

The velocities in the liquid line of a unit varies with the density of the liquid and with its viscosity. These velocities may vary between 50 to 200 feet per minute, depending upon the refrigerant used. For instance: Freon should have

velocities no greater than 100 feet per minute while methyl chloride may have velocities as high as 200 feet per minute.

For example: If 75 cubic inches of liquid were used a minute, the internal cross sectioned area of the liquid line to keep the liquid line velocity at 100 feet per minute or below would be:

$$\frac{75}{100 \times 12} =$$

Cross section area = .063 sq. in.

The inside diameter $= \frac{.063 \times 4}{\pi} = .285$-inch. Use a $\frac{3}{8}$-inch O.D. tubing. It is very important that these refrigerant carrying lines be of sufficient capacity; the cost of increasing the tubing size is so small in comparison to the total cost of the machine, that there is no real necessity for calculating the size of these tubings to too close limits. At least a 50 per cent oversize of the tube is therefore recommended.

Bends and fittings increase the resistance to the fluid flow. It is claimed that there is as much friction to flow in a 90° elbow as there is in 10 feet of straight tubing of the same size. The friction in bends, fittings, and the normal friction of fluid flow through the tubing must be calculated when figuring gas velocities.

The liquid line problem has another feature which needs an explanation; that is, the size of the orifice opening, which is controlled by a needle, must be calculated. Its size depends upon the shape of the opening, upon the viscosity of the liquid passing through it, and upon the pressure difference as the fluid passes through the orifice. These orifice sizes, however, become fairly standard for domestic and commercial machinery with orifice openings of 0.93-inch and .156-inch being adapted as most popular. If larger orifices are needed

multiple installations of expansion valves are used. See Figure 283 for a table of orifice sizes and capacities.

Control and Manufacturer	Sizes for So_2	Sizes for Methyl	Sizes for Freon	General
Automatic Expansion Valve Fedders	.063	.063	.063	.063 Standard .093 Special .156 Special
Thermostatic Expansion Valve Fedders	.093	.093	.156	.093 Standard .156 Special
#672 Automatic Expansion Valve Detroit Lubricator.	.078 Standard 1T Spec. .156 2T	.078 2T .156 4T	.078 1T .156 2T	
#673 Thermostatic Expansion Valve Detroit Lubricator.	.078 1T .125 1½T .156 2T	.078 2T .125 3T .156 4T	.078 1T .125 1½T .156 2T	Special Special
Automatic Expansion Valve Riley "D"	.093	.078 Standard	.093	.093 Special .125 Special .156 Special
Thermostatic Expansion Valve Riley "E"	.093 ½T .125 1T .156 2T	.093 1T .125 2T .156 4T	.093 ½T .125 1T 156 2T	Special Special

T = Tons of refrigeration capacity.

Fig. 283. A table of expansion valve orifice sizes and capacities

867. REFRIGERANT LINE CAPACITIES (SUCTION):

In a suction line the gas velocity depends upon the low side pressure of the system and, therefore, in its application the

velocities usually used are between 800 and 5,000 feet per minute. Figure 284. As the refrigerant evaporates in the cooling coil, its pressure must be somewhat higher than the gas pressure in the crankcase before it will go down the suction line. The compound gauge, mounted on the compressor, will show the compressor crankcase pressure which is lower than the actual pressure in the cooling coil. The suction line involves two additional problems in the understanding of the pressure drop within the line. One additional complication is due to the necessity of returning oil to the compressor by means of the suction

Refrigerant	Allowable Velocities in Feet per Minute		
	Suction Line (Gas)	Condenser Vel. (Gas)	Liquid Line Vel. (Liquid)
Ammonia	4000–5000	5000–6000	100–250
Methyl chloride	1000–2000	2000–2500	100–200
Sulphur dioxide	1000–2000	2000–2500	100–200
Freon	800–1800	1800–2250	80–100
Water	30–50 (Liquid)		100–250

Fig. 284. Allowable refrigerant liquid and suction line velocities
(Courtesy of: American Society of Refrigeration Engineers)

line. Also, when two or more coils are connected to one compressor, the resistances to flow in the different lines may cause the pressure on the surface of the refrigerant in the various coils to vary as much as 2 pounds per square inch to 3 pounds per square inch. The friction in a ½-inch O.D. suction line is approximately .25-inch mercury (Hg) per 10 feet of length with a gas velocity of 1,000 feet per minute. This results in a problem of balancing cooling units. The amount of pressure drop becomes greater as the length of the suction line increases, as the cross sectional area of the tubing decreases, and in proportion to the number of bends

and fittings in the suction line. The oil return should be taken care of by slanting the suction line consistently downward from the cooling coil to the compressor to permit the oil drain naturally into the compressor. If a low spot is constructed into the suction line, the oil will accumulate here and decrease the cross sectional area of the tubing, causing an orifice action which also decreases the efficiency of gas flow. Figure 285. Furthermore, when this low spot eventually becomes filled with oil, the pressure builds up and the oil is slugged into the compressor. This slugging of the oil in

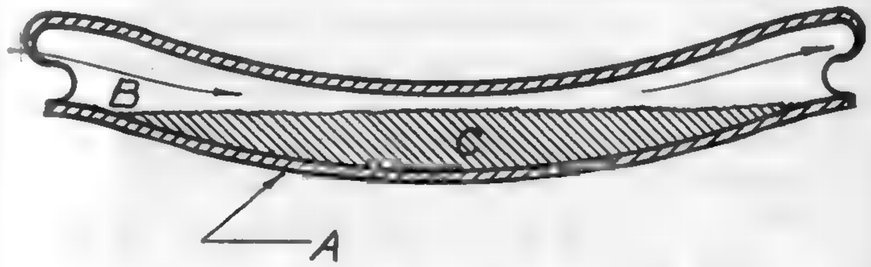


Fig. 285. Illustrating the restricting of gas flow due to the collection of oil in a low spot in a suction line.
A. Suction line; B. Refrigerant gas; C. Oil

the crankcase of the compressor accelerates oil pumping momentarily.

808. REVIEW QUESTIONS:

Answers to the following questions may be found on page 828.

1. What is a B.T.U.?
2. What is the B.T.U. equivalent of a H.P.?
3. What is sensible heat?
4. What is latent heat?
5. What is specific heat?

6. Why is it important when calculating the heat load of a cabinet to know what the cabinet is used for?
7. Why is the heat leakage into a cabinet based upon the external area?
8. What is the purpose of a baffle?
9. Why must a horizontal baffle be insulated?
10. What materials were used for the interior walls of the older cabinets?
11. What is the purpose of the ice hold-over in the sweet water bath?
12. Why must a pressure type water cooler never be allowed to accumulate too much ice?
13. What is the specific heat of ice cream?
14. At what temperatures should brick ice cream be maintained?
15. How many pounds of walnut ice cream are there in a gallon?
16. What is meant by the superheating of the gas in the suction line?
17. What is the "effective latent heat" of a refrigerant? Why is it different from latent heat?
18. What causes the superheating of gas as it passes through the compressor?
19. Why may one use the B.T.U. added to the gas as it goes through the compressor to calculate the size of the motor to drive the unit?
20. What is meant by volumetric efficiency, and what variables influence it?
21. What factors must be considered when determining the type of compressor drive?
22. What is meant by motor efficiency and what are the usual efficiencies?
23. Explain how heat travels from one carrying medium to the next, starting with the refrigerated cabinet and continuing to the suction line gas, describing the ease of transfer from one medium to the other.
24. Why does the air speed over an air-cooled condenser affect its capacity?
25. What effect does an oil film on the condenser tubing have on heat transfer?
26. Explain the increase of the gas pressure in a suction line as the distance from the compressor increases.
27. Can one have a saturated gas without any of its liquid being present?

CHAPTER XV

COMMERCIAL REFRIGERATION INSTALLATION AND SERVICING

The majority of commercial refrigeration apparatus necessitates a rather complicated installation because usually more than one cabinet is connected to a single compressor. The size of the units are such that the assembly work of the complete system must be performed on the premises. The small units of the package type construction do not necessitate this complicated arrangement; instructions for installing and maintaining them will be found to be very similar to those in Chapter X for domestic machines. For example, a self-contained water cooler for an office necessitates only three connections. Electricity is obtained by means of a plugged in connection, and a plumber will be quickly able to connect the water and attach the drain to the system.

Multiple installations must be installed to handle the refrigeration load efficiently and must be set up to minimize the chances of accidents. All installations should be made with permanency and neatness as the two main objectives. Many cities have laws and codes designating how and where certain refrigerating apparatus should be installed. See Paragraph 453 for national code. Also many refrigerating companies have rules directing how their equipment should be installed. Previous to the time cities and the manufacturers systemized their procedures, many installations were made with the workman's own ideas incorporated in the job. Small cities and rural communities are not restricted by code, and installations are usually put in at a minimum cost. One must, therefore, consider two types of installations:

1. The code installation
2. The non-code installation

The servicing of commercial installations in some respects is similar to that of the domestic unit. However, the use of multiple cooling coils on a single compressor, and the use of the thermostatic expansion valve, plus the almost exclusive application of water-cooled condensing units, necessitates a rather detailed study of how these commercial units may be serviced. The troubles encountered come under various headings such as, no refrigeration, continuous running, a high electric bill, poor refrigerating temperatures, frosted suction lines, etc. Servicing information in this chapter deals mainly with the systems, what goes wrong in them, and how to repair them. Much of the servicing is similar to that followed in domestic practice and the material in Chapter XI may be used to a considerable extent. The tools listed in Chapter XII are usable for commercial servicing.

869. NON-CODE MULTIPLE INSTALLATIONS:

A definite routing should be closely adhered to when assembling a multiple system in order to safeguard against any faults in assembly, and to eliminate careless procedures which refrigeration service departments claim produce more than 90 per cent of the servicing difficulties. Assuming that the problem has been completely solved from the heat load angle (Chapter XIV), and that the units are well proportioned and of such a size that they will efficiently handle the load, the proper installation must be made in a way to take full advantage of these factors. In a non-code installation, the tubing connecting the units to the compressor does not have to be protected in any way except as to the location where it is run; such items as safety valves and protective devices do not have to be incorporated in the installation.

870. LOCATION OF THE CONDENSING UNIT:

The first problem to be solved is the location of the con-

densing unit in respect to the cabinet. Figure 286. It is only natural that this location should be as close to the

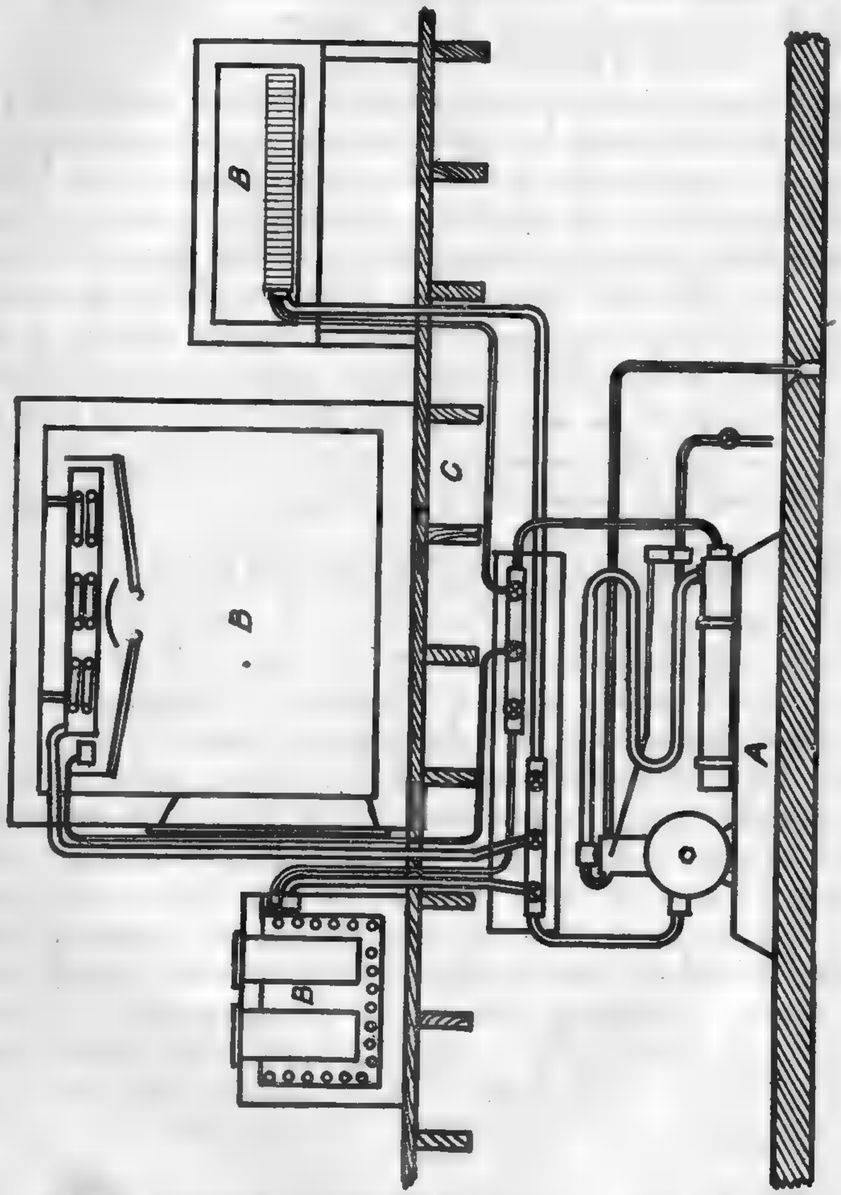


Fig. 286. A typical non-code installation
A. Condensing unit; B. Cabinets; C. Floor line

various cabinets as possible, i.e., a central location. It is recommended that the condensing unit be put in the basement

or in an adjacent room to the one in which the cabinet is located. Locating the condensing units in the same room with the counters and boxes is often somewhat disturbing because of the noise produced. The location of the condensing unit must also be governed by the source of electrical supply, water supply, and water drainage. The proportioning of the cost as to the running of the electrical lines and the refrigerant tubing is a local problem, but most refrigera-

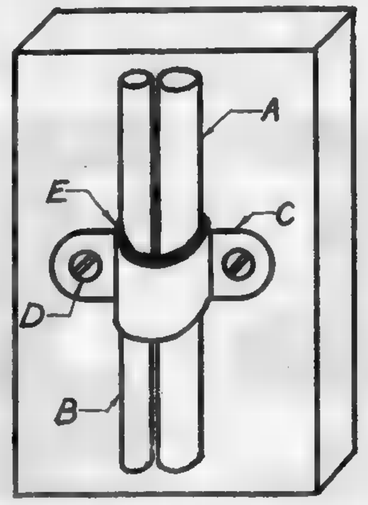


Fig. 287. A method of fastening the tubing to the wall
A. Suction line; B. Liquid line; C. Clamp; D. Wood screw; E. Friction tape

tion service men prefer to minimize the electrical work and extend the refrigeration lines, if necessary, because it is more in their own field. This idea is basically uneconomical, because of the reduction in efficiency of the condensing unit when the tubing is run a long distance. The condensing unit should be mounted on a cement base, if possible, and hold-down bolts are absolutely necessary to keep the unit stationary. The unit should be mounted level. These commercial condensing units are provided with a base which usually permits mounting the condensing unit on the floor. How-

ever, when the floor is moist and when the floor is dustier than normal, a stand should be constructed of wood or cement to enable mounting the unit 20 inches to 40 inches above the floor. A flimsy base will magnify any vibrations or sounds and should not be used.

371. TUBING (NON-CODE INSTALLATIONS):

The tubing in non-code installations is usually run along the walls and ceilings; it is supported only at intervals frequent enough to keep the tubing straight and firmly in place. Special clamps are manufactured as tubing fasteners, but

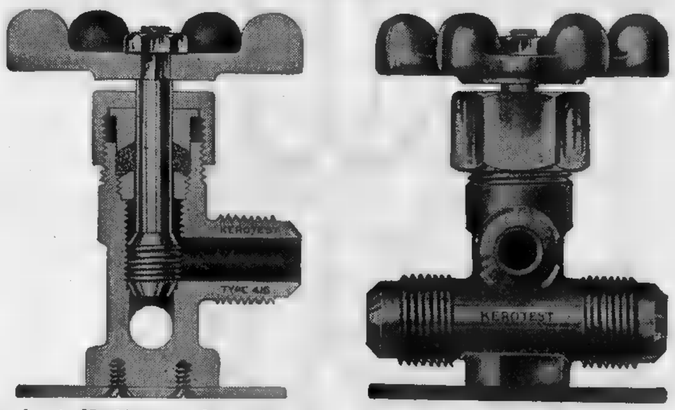


Fig. 288. An installation valve showing the means for mounting the valve on a panel
(Courtesy of: Kerotest Mfg. Company)

one will find that a galvanized conduit clamp of the ½-inch size is sufficient for most of the situations. Figure 287. The tubing should be insulated from these clamps or protected from them by means of a short wrapping of friction tape to prevent chafing. Where the tubing is run through the floor or wall, it should be adequately protected by means of short runs of conduit, or flexible metal tubing (Greenfield), and the ends sealed up with some sealing compound, otherwise chafing of the tubing and corresponding troubles are likely to result. Figure 288. The tubing in all cases should be run horizontally and vertically with neat looking bends of as perfect a radius as possible. The liquid line presents no difficulties as to its slant and position, but one must always install the suction lines so that the tubing will drain into the compressor. Any low spots in the suction lines will act as accumulators of return oil, and will eventually form a liquid slug in the tubing; when this is carried to the compressor it will cause some disturbance in the crankcase, resulting in temporary oil pumping. If the tubing must slant upward on returning from the cooling coils to the condensing unit, the construction should be made to permit a steady downward slant of the tubing to a certain point at which a U-bend is located. The U-bend will act as an oil trap, functioning as the low spots mentioned above, insuring a positive return of oil to the compressor. This is poor practice, however, and should only be used as a last resort.

372. COOLING COILS (NON-CODE INSTALLATION):

The installation problem varies as to the type of refrigerant control, and whether the condensing unit is water-cooled or air-cooled. If flooded cooling coils are used, the proper procedure is the following: The condensing unit and the cooling coils should be mounted and firmly fastened in their respective places. The cooling coils are usually fastened to the ceiling of the cabinet if it is either a grocery, a florist walk-in cooler, or the like. Display counter coils are usually supported from underneath the coil by stands. These stands or brackets should be provided with an adjustment, because the basic construction of a low side float necessitates that it be level in all directions in order to operate successfully. These hangers in the case of the low side floats are usually made of galvanized strap iron ⅛-inch × ¾-inch. In case the strap goes around the float chamber, a clamping device should be

provided to attach the coil firmly to the hanger. The hanger may be attached to the ceiling of the cabinet in one of three ways. It may be bolted directly through the cabinet ceiling with galvanized or cadmium plated carriage bolts, or the hanger may be fastened to a sheet of steel by means of cap screws (both of these being plated to prevent rusting), and the plate in turn is fastened to the ceiling of the cabinet by brass wood screws. The third method is to fasten the bracket directly to the ceiling by means of wood screws. The first method is considered the best, although it is a little difficult

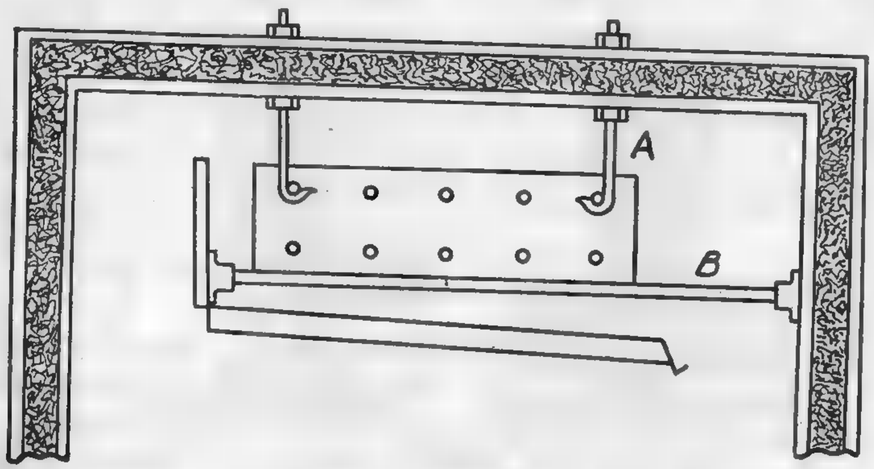


Fig. 289. Showing two coil mountings which may be used for either low side float coils or dry coils
A. Suspended from the ceiling; B. Horizontal pipe mounting

to install in some cases. Figure 289. If none of these are workable for the particular installation, horizontal steel piping fastened to the walls of the cabinet may be used as supports for the coils, or the coils may be supported from underneath by a stand which is fastened to the baffles in the cabinet. These later devices make it rather difficult to mount the coil in a level position and to keep it in a firm position. Regardless of the devices used to mount the coil, they should

be rechecked after being put in operation to insure that they are level.

874. INSTALLING THE TUBING:

As previously stated in the text, copper tubing comes in coils usually of 50-foot lengths, and the tubing is sealed at the ends and dehydrated. In the average commercial installation ¼-inch tubing is used for the liquid line and ½-inch tubing is used for the suction line. It is only in cases such as large installations and sizable air-conditioning systems that a larger, liquid-line tubing is required. Only the very largest commercial installations use a larger suction line tubing than ½-inch, although practically all the air-conditioning installations use larger tubing. This tubing during the period of installation should be kept as clean as possible; one should never allow the tubing to be put aside with the ends open. If possible all tubing should be put in place before being unsealed. One must seal the tubing if it is not to be used for a period of 5 minutes or more. See Paragraph 224, for tube sealing instructions. The most practical method of installing this tubing is to uncoil 10 feet of it at a time by unrolling the coil along the floor and then run it up through the floor openings from underneath, gradually working the tubing into place. One will not have any difficulty in installing the ¼-inch tubing, but ½-inch tubing must be rather carefully handled to prevent buckling at the bends. Bending jigs of all sorts are available for bending the tubing and should be used. In a non-code installation where the individual suction lines and liquid lines run into the main lines, "Tee" connections may be used and the valves for shutting off the individual coils may be located near the coil itself. These connections may be of the 45° S.A.E. flare type, or of streamline fitting construction. The most serviceable installation may

be made with the use of streamline fittings or flange fittings inside the cabinet; one has the choice of streamline fittings or flared connections outside the cabinet on the tubing runs between the cabinet and the condensing unit. Whenever tubing is installed it should be immediately sealed after the flare or streamline connections are made to keep it as clean as possible and the tubing should be attached permanently to the supports along which it runs. Always run the tubing in such a manner that the construction of the support protects the tubing from any accident. That is, do not place it in such a position that a person carrying an object through a doorway or around a corner is liable to catch the tubing and strain it excessively, or do not put it in such a place that it is open to abuse from the handling of articles in that room. Do not put any loops or unsupported bends in the tubing except at the condensing unit.

375. REMOVING THE AIR (FLOODED COIL SYSTEM):

All commercial flooded coils, that is, coils using the low side float refrigerant control, are charged with the proper amount of refrigerant and oil before they are shipped to the place of installation. This means that the coil must be equipped with a suction line service valve and a liquid line service valve. After mounting these coils in their respective cabinets, remembering to keep them perfectly level, one must install the tubing as previously mentioned; after all the tubing is mounted and all the fittings are put in their respective places, the following procedure is believed to be best to insure correct operation of the unit. The liquid line lead from the condensing unit to the various coils is rather difficult to prepare for use because at the ends of the liquid lines a quantity of refrigerant is stored making it impossible ordinarily for the service man to pump a vacuum on this

part of the system. One of two things that may be done is to purge the lines. To do this, close all the hand shut-off valves located at the various junctions of the low side coils to the main liquid line, that is, turn them all the way in. The extreme fitting on the main liquid line farthest from the condensing unit should then be loosened and the liquid receiver service valve cracked. This will permit a quantity of the refrigerant to surge along the main liquid line forcing the air ahead of it and out the loose connection at the extremity.

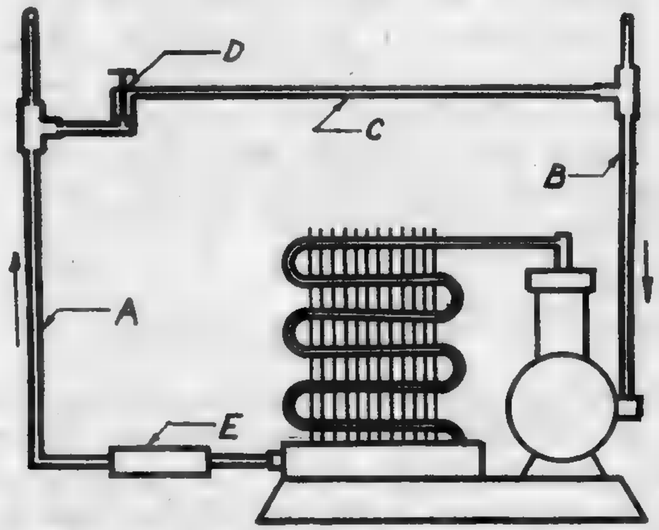


Fig. 290. A by-pass line for emptying and evacuating liquid lines
A. Liquid line; B. Suction line; C. By-pass line; D. Shut-off valve; E. Strainer

It is best to allow a little refrigerant to flow out with the air that is being purged. Since most low side float installations use sulphur dioxide, purging with refrigerant is somewhat unpleasant. However, if one holds a cloth partly saturated with aqua ammonia close to the opening through which the air is being purged it will neutralize the fumes. Tighten this fitting firmly after this procedure is finished. Next loosen the liquid line connection to one of the cooling coils. Crack the hand shut-off valve which is used to connect this liquid

line to the main liquid line and tighten the fitting after this line has been purged. Continue this procedure for all of the liquid lines. If this job is done carefully, the installation man may be sure that he has removed approximately 90 per cent of the air from the tubing.

Another method used by many installation men is to connect a by-pass line from the liquid line to the suction line near the compressor. Figure 290. This line is controlled by a one-way hand valve and may be used to pump a vacuum on the liquid line. In detail, the compressor pumps a vacuum on the suction lines first; then with all the liquid line valves closed, the by-pass valve is opened allowing the vacuum to be pumped on the liquid lines also. Purging the lines may also be performed when one uses this method. The following paragraphs will explain some further uses for this by-pass valve.

376. EVACUATING THE SUCTION LINE:

To remove the air from the suction lines a different procedure may be followed, or one may use exactly the same procedure as described above. The usual procedure is to pump all of the air out of the suction lines by using the compressor as a vacuum pump. In detail, one must put a compound gauge on the compressor suction service valve and remove all the refrigerant from the crankcase of the compressor by drawing a 20-inch vacuum or more. *Be careful of oil pumping.* Then install a purging line into the gauge opening of the discharge service valve. Run this line out-of-doors. Turn the discharge service valve all the way in, shutting off the condenser opening. Now turn the suction service valve almost all the way out and pump a vacuum on the suction lines. The air being removed will be discharged out the purging line. This line may be run either out of doors or

into a sewer, or in some cases may be purged into the room where the condensing unit is located. After creating as high a vacuum as possible with the compressor, which means that 70 per cent to 75 per cent of the air in the suction line has been removed, the extreme cooling coil suction line valve may be cracked very slightly. This will permit a very small quantity of the refrigerant to come down the suction line; when this has been pumped from the system, the amount of air left in the suction line will be negligible.

377. TESTING FOR LEAKS:

After these two lines have been cleansed of air, the unit is ready to operate, but should be very carefully checked for leaks first. The best possible way to locate leaks in any system is to build up a pressure of 40 pounds per square inch in all parts of the system. In case a low pressure refrigerant is used or if the local code specifies a pressure test above the refrigerant's vapor pressure some other gas may be used for testing. Carbon dioxide or nitrogen should be used. *Caution: Never use oxygen or any inflammable gas for this purpose.* This should include the liquid line and suction line of this particular installation. After building up a 40 pounds per square inch pressure, the various means for testing for leaks should be used and checked over very carefully. See Paragraphs 189 to 193. A small leak is very hard to find, and unless a very careful leak checking routine is followed will eventually result in considerable trouble. The cost of the refrigerant to be replaced and the hazards to food and human comfort makes checking for leaks a paramount requirement. If the motor control has not been already adjusted for the installation, this should be done at this time before the system is set in operation. The settings of the motor controls will vary with the demands of the cabinets and with the various

kinds of refrigerant used. Be sure the water is turned on in case it is a water-cooled condensing unit, and that the fuses in the electric circuit are the right size.

378. STARTING THE UNIT (LOW SIDE FLOAT SYSTEM):

Open all the liquid line and liquid receiver valves. Start the compressor. When starting a completely warm installation of this kind if the cooling coil low side pressure is permitted to go into the crankcase of the compressor unreduced, an excessive load will be imposed upon the compressor and motor and serious harm is likely to result. Since the compressor pulls down the low side pressure very rapidly, the following procedure is believed to be the best. After starting the unit, open the suction line valve on the various cooling coils, one at a time at 10 minute to 15 minute intervals and open each very slowly. It should take at least 2 minutes to open each of these suction line valves two turns. This procedure gives the compressor time to reduce the high pressure gas on the low side. After all the cooling coils have been opened and everything is running normally, the service man should stay on the premises for at least an hour checking the operation and he should return within 24 hours to determine how the system is performing. The checking of the system should include the high and low side pressures, vibration of the unit, the amount of water flow in case of a water-cooled system, and the temperatures of the suction lines at the cooling coils to find out if they are flooding back due to an out-of-calibration float or a leaky needle. It is recommended that an installation of this kind be checked with a 24-hour thermograph after the unit has settled down to a routine cycle. Paragraph 448.

879. REMOVING THE AIR (DRY SYSTEM):

After the tubing has been installed and connected with a thermostatic expansion valve system, the service man should evacuate the system and remove the air from the newly installed parts in a manner similar to that described in Paragraph 375. Most dry coils are fitted with lead caps to prevent moisture and dirt from entering them during shipment and installation, but these caps are not always air-tight. This means that the coils should be evacuated just as thoroughly as the liquid and suction lines. The best procedure for cleaning this part of the system is to evacuate it, using a method very similar to that described for removing air from the low side float coil installation. This procedure as stated before is the method whereby air is pumped out of the lines and the coils into the open air, and the liquid receiver service valve is then cracked. The only valve to be kept closed during this procedure is the liquid receiver service valve. All the others are to be as far open as possible, permitting the evacuation to work on all parts of the system. After all the air has been removed and the unit purged, the service man should test for leaks using a 40 pounds per square inch pressure throughout the system. The leaks should be carefully looked for because, as previously explained, this is one of the most important steps in an installation of any kind.

880. STARTING A DRY SYSTEM:

Thermostatic expansion valves when they are warm are completely open and to start the system with the full load of all the coils on it, the compressor will be overloaded, as in the low side float installation. Therefore, all liquid line valves should be closed and the condensing unit started. These valves may then be opened one at a time, requiring two

minutes to turn the valves two revolutions. It is a very important precaution in refrigeration never to overload the compressor even for very short intervals. After one coil has been opened and after a 15-minute interval of operation, the coil has a chance to cool down somewhat, tending to make the expansion valve throttle off the refrigerant. This gives the compressor a chance to gradually reduce its load. The remainder of the coils may then be brought into service in the same way. The service man, after starting the unit, should check the high and low side pressures, the amount of waterflow in case it is a water-cooled system, and the operation of each individual expansion valve. Also determine if the adjustment is correct for each coil; that is, the frost on the suction line will indicate whether or not the expansion valve is opened too far or not far enough. Another very important procedure or routine to be followed at this time is to determine whether or not the system has enough refrigerant. This should be done as described in Paragraph 406.

381. MULTIPLE CODE INSTALLATIONS:

Many localities now have very definite rules and regulations pertaining to the installation of refrigerating equipment of all kinds. The code covers the various classes, but pertains mostly to industrial and commercial refrigeration. Domestic units are not usually included on code regulations because the manufacturers of these units cover in detail all the necessary requirements. In commercial installations, where the units are assembled on the premises, there are certain requirements that must be adhered to in order to insure a uniformity of performance and to make the installation as satisfactory and safe as possible. Installation codes also protect the purchaser from careless installations made by untrained persons or made in such a way as to be maliciously

criminal. Most cities have a code of this nature and some of the high points of all the codes are the following: tubing is to be run in conduit, valves must be located in adequate steel boxes, the electrical and plumbing work must be done by licensed electricians and plumbers respectively, the system must be tested under certain pressures on both the high and low side, and it must be free from leaks. See Paragraph 453 for the recommended national refrigeration code.

382. CONDUIT:

The problem of making an installation with the tubing run in conduit is similar to making an electrical installation. The conduit is mounted in the desired places by means of conduit

Fig. 291. A section of flexible metal tubing (Greenfield)
(Courtesy of: Harry Alter Company)

brackets, and the ends of the conduit are then attached to boxes or to "Greenfield" tubing. Since conduit comes in lengths of 10 and 20 feet, and because it is difficult to bend, fittings and boxes are used at turns. Bends in the conduit would necessitate pulling the tubing around corners which very likely would cause buckling of the tubing at these points. Therefore, in place of bends in conduit, the code calls for one of two types of construction. One is to use a box at the bend, run the tubing inside this steel box, and make bends in the tubing by means of elbows or fittings. Another method is to bend the tubing and then protect it by means of "Greenfield," which is a flexible steel tubing. Figure 291. The most popular method and the one recommended is the use of steel boxes at the bends. "Greenfield" is much easier to install

than solid wall conduit, and for that reason tends to be popular, but many of the codes restrict its use to lengths not to exceed 5 or 10 feet. "Greenfield" is popularly used where the tubing is run from the walls to the boxes and from the condensing unit to the walls. The conduit comes mainly in 1-inch sizes although the 1½-inch size is also used. The conduit is usually used because its thin wall construction cannot be threaded and therefore special fittings are used to

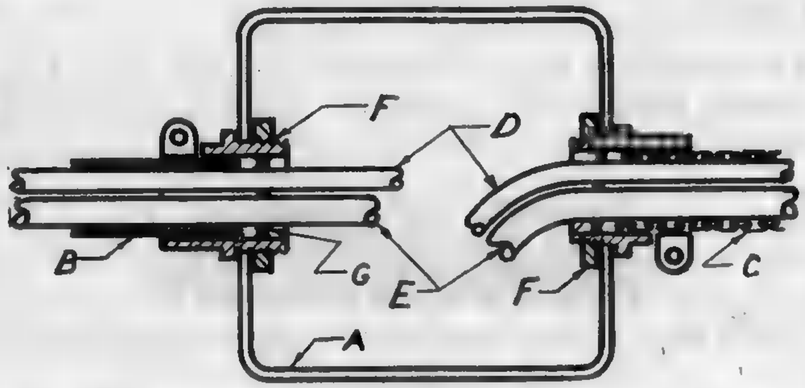


Fig. 292. An illustration showing a steel cabinet with a conduit connected to it A. Steel cabinet; B. Thin wall conduit; C. Flexible conduit; D. Liquid lines; E. Suction lines; F. Lock nuts; G. Sealing compound

fasten it to Greenfield tubing and to the steel boxes. Figure 292. After the conduit and the boxes have been installed, the tubing is then drawn or pushed through the conduit. Steel tape is often used to pull the tubing in places where it is difficult to install, using methods similar to those in electrical practice. This conduit is usually installed between the walls in new buildings, and the installation presents no difficulties; but in buildings already finished the problem is more difficult, depending upon the cleanliness of the job desired. It is very easy to install the conduit outside the wall, but the appearance must be considered. All the installations through plaster

walls and through plaster ceilings should be priced with the replastering and redecorating cost kept in mind.

883. VALVE CABINETS (CODE FITTINGS):

Special steel boxes of about No. 14 gauge metal, provided with hinged doors, lockable or otherwise, are provided with plugged openings along the sides. These openings are along the top, sides, and bottom and are usually staggered 1-inch and 1½-inch diameter. The openings desired are punched out and the conduit joint is firmly made by means of the special thin conduit union. The valves located inside the box, or the fittings located therein, are to be fastened to the wall. Some difficulty will be incurred occasionally in making the necessary connections inside these steel boxes because of the bends required and the small space available to do any flaring. This may be helped somewhat by allowing some slack in the tubing in all but the last box.

884. VALVES (CODE INSTALLATIONS):

All valves used in these cabinets are to be hand operated, that is, the law requires that these valves be of such construction that anyone may shut them off on short notice without the need of special tools. These valves are of two common styles. One incorporates a valve key in the cap covering the valve stem, and the other uses a hand wheel mounted permanently on the valve. These valves are provided with brackets whereby they may be attached firmly to the steel cabinet. The valves come most commonly in a style whereby turning the valve it shuts off just one of the three connections made to the valve. The other two, remaining uncontrolled, permit the passage of refrigerant to the remainder of the system. The older style valves were of the lead and graphite packing style, but packless valves are now

becoming popular. A typical box installation will have three conduit pipes running to it. One conduit contains the suction and liquid line from the compressor; another continues these lines to the other units of the multiple installation, and the third contains the tubing to the coil which the hand valves in that particular box control. This installation is typical because most of the codes require that each low side or cooling coil be equipped with individual hand shut-off valves. The manipulation of the code installed unit upon starting, to insure long and efficient refrigeration, is precisely the same as described in starting the non-code installations. Paragraph 380. This does not complete the installation regulations, however, because in all code installations an inspector is usually assigned to check over the installation before the unit may be operated.

385. TESTING (CODE INSTALLATIONS):

Code authorities require that permits be taken out before the work is started. Specifications of the proposed installation are presented for a permit. Permits are not issued unless specifications presented meet the code requirements. On completion of the installation the inspector is called and his sanction must be given before the unit may be run. Some localities require that the refrigeration installation men be licensed, but most localities require only the obtaining of the permit. The inspector upon reaching the premises, checks the installation to see if all the work has been done according to specifications and code, and then proceeds to test the system. His testing primarily consists of checking for leaks and checking the unit for safety. He does this by building up the required pressures in the high and low sides of the system. These pressures vary with the kind of refrigerant used in the system. If no leaks are indicated at the pressures

established, the inspector sometimes checks the system further by producing a vacuum on all that part of the system and if this vacuum is maintained over a certain period of time the installation is approved. These code regulations have eliminated many troublesome features in the installation work. Most of the larger refrigeration companies followed these methods long before they were required by law because code rules are only a statement of good safe practice which insures satisfactory operation of the installation. The main reason for protecting all tubing in conduit is to safeguard the tubing from any injurious blows or loads and from such dangers as drilling into the wall and the like. Experience has shown that code installations are necessary, especially if the tubing is run within the walls.

386. TWO-TEMPERATURE VALVES:

Many multiple installations involve several boxes of different temperatures connected to one condensing unit. This necessitates the use of two-temperature valves. There are three kinds of two-temperature valves as explained in Paragraph 302 and each has its definite application. The metering type, two-temperature valve is used very commonly in ice cream and soda fountain combinations in which the ice cream must be maintained at around 50°F., the beverage coolers must be kept at about 45°F., and the storage chamber kept a different temperature. The two-temperature valves used to permit this condition should be installed at the union of the warmer coils suction line with the main suction line and, therefore, takes the place of a "Tee" fitting; however, this connection may be at any place on the suction line because its operation is usually not affected by the distance from the coil. Frequently this valve may be found located in the soda fountain, although many are located near the condensing unit. Figure

212. This type of installation is usually improved considerably by mounting a check valve in the suction line of the coldest coil to prevent the backing up of the higher pressure gases into it; also a surge tank should be mounted near the condensing unit and connected between the compressor and the main suction line to cut down the rapid fluctuations of the low side pressure. In most code istallations the two-temperature valve and the check valve must be mounted in a

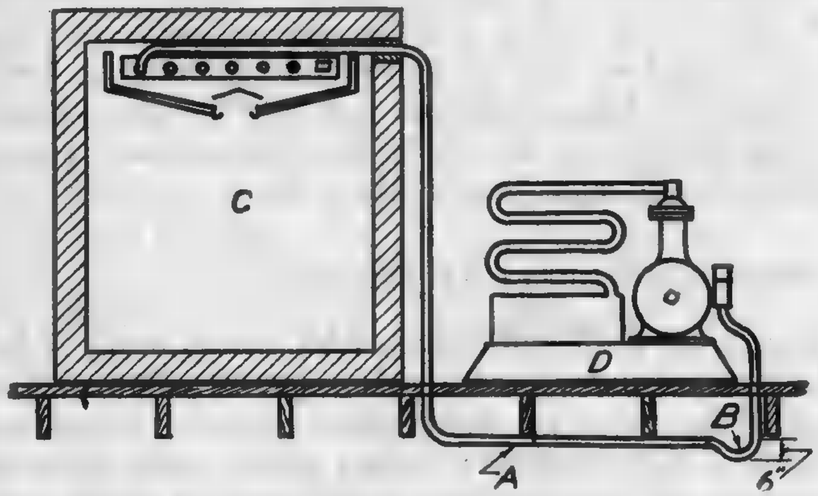


Fig. 298. An illustration showing the method of returning oil to a compressor when the suction line comes from below the compressor
A. Suction line; B. U-Bend or trap; C. Cabinet; D. Condensing unit

steel cabinet, and the surge tank must be mounted on the condensing unit base.

387. THE COMPRESSOR LOCATED ABOVE THE COIL:

Occasionally an installation will involve the problem of locating a cooling coil below the level of the compressor. This installation presents one particular problem. As has been explained, the oil used to lubricate the moving parts of the system circulates to some extent with the refrigerant. This

circulation depends upon the ability of the refrigerant to absorb oil when the liquid refrigerant is under high pressure in the high side; but when the liquid refrigerant is admitted to the low pressure side and vaporizes, it loses the power to retain the oil. The oil, therefore, collects in quantities in the low side and in the normal system drains down the suction line to the compressor. If the compressor is located above the coil, however, this cannot be quite so easily accomplished. Therefore, the following method has been devised to overcome the difficulty in returning oil from elevated condensing units. Slant the suction line downward to a point just below the compressor, and at the junction of the slanting suction line with the vertical line running up to the compressor, install a U-tube in the line. Figure 293. The operation of this fixture is as follows: the oil flows down the slanted suction line and accumulates in the U-tube; when enough of it has accumulated to block or fill the U-tube passage, the compressor, pulling a low pressure on the vertical tube, will slug the oil up the vertical run and into the compressor. This action occasionally disturbs the oil in the crankcase in the compressor to such an extent that oil pumping results from the action. Because of this, the installation is not recommended. The condensing units should always be placed lower than the coils for the best operation of the system.

388. STREAMLINE FITTINGS:

The size of commercial units have been increased quite steadily in the last few years and some units now have as much as 20 tons capacity. This is especially true with summer cooling or comfort cooling installations in air-conditioning plants. The sizes of the liquid and suction lines in these installations are frequently $\frac{3}{8}$ inch and 2 inches in diameter respectively. It is evident that flaring a 2-inch line is out of

question. For this reason and because of other natural advantages of the joint, streamline fittings have become very popular and are used almost exclusively on large units. These fittings as described in Chapter XII consist of a drop-forged fitting with a machined recess of sufficient size to receive the tubing. The clearance between the two is a matter of a few thousandths of an inch. When this joint is heated and solder is fed to the surface, capillary action draws the solder into the space between the two, forming a very strong joint. There are available two kinds of streamline fittings for use in this kind of work. One style involves the use of soft, seamless, annealed copper tubing, which is the tubing used exclusively in domestic work. The other used is hard drawn copper tubing which is seamless and has approximately the same wall thickness as the annealed copper tubing. It comes in 10- or 20-foot lengths rather than in rolls. The ends are either capped or plugged. The fittings used with this tubing are similar to the drop-forged, refrigeration, streamline fittings. The tubing is brazed or soldered to the fittings as explained above. When making an installation of this kind, extreme care should be taken to use the fluxes and solders recommended by the manufacturers, and also to have the ends of the tubing square to prevent any solder from running into the tubing. See Paragraph 440 for detailed specifications of this tubing.

389. TINNED TUBING:

Copper tubing normally comes with no special finish provided for the inside or the exterior surface. This permits the copper to become corroded if exposed to certain corrosive elements, such as running the tubing through liquid or through air saturated with acid fumes or corrosive elements of any kind. In places where sanitation is of primary importance, tubing with a tinned surface always is used. A typical example of this is the installation where the copper tubing runs into a cabinet and is connected to the cooling coil. That portion of the tubing inside the cabinet is subject to the moisture saturated air of the cabinet and eventually becomes corroded. Using tinned tubing prevents this. One company uses tinned tubing exclusively, because this company believes that the sanitation aspect is important enough to warrant the extra expense. Where the copper tubing is used to convey beverages such as beer between the kegs and dispensers,

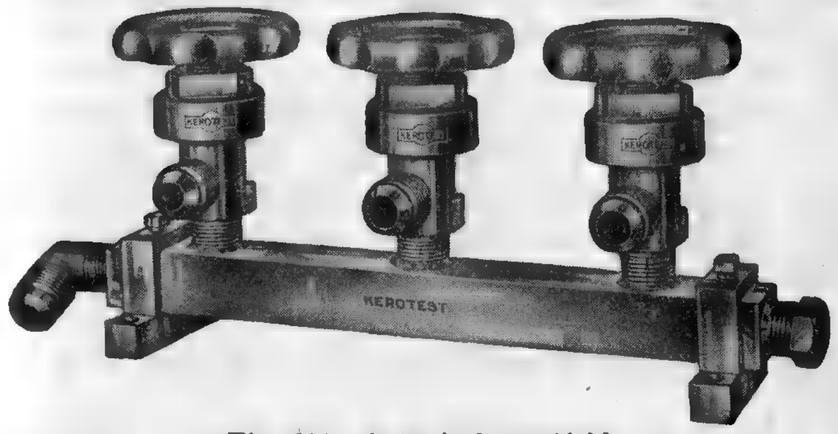


Fig. 294. A typical manifold
(Courtesy of: Kerotest Mfg. Company)

or used to carry the cooling water to and from the condensing unit, the interior of the copper tubing should be tinned. This will insure a maximum of sanitation for the beverage tubing and a maximum life for the cooling water tubing. This is called blocked tin tubing.

390. COIL CONNECTIONS:

There are two common methods of installing a multiple installation as it concerns the running of the tubing. One method is to have a common liquid line and common suction

line and to tap the various cooling coil liquid and suction lines to it at the most convenient points. The other method is to use a clustering system wherein all the various lines are brought to a common point and connected through a hand valve to a manifold, and from this point to the compressor a larger suction or liquid line is run. Figure 294. The latter method predominates at the present time and is the neater and more convenient installation to use. This method does not have to be strictly adhered to in cases where one coil is at some distance from the box, necessitating a duplication of long runs. The manifold, as stated previously, must be installed in a steel cabinet, in case of a code installation, and the location of this manifold is usually on the wall near the condensing unit. An important item to be kept in mind at all times is that every fitting used, and every bend put into the refrigerant and suction lines, decreases the efficiency of the installation; one should try to minimize the number of these as much as possible.

391. AIR-CONDITIONING INSTALLATIONS:

This term applies to all refrigeration installations involving the cooling of air to promote the comfort of persons within an establishment. The sizes of these units vary from a small package type cooler up to many hundreds of tons of capacity. However, most installation men, unless they are assigned to air-conditioning especially, deal only with the smaller portable or semi-portable air-conditioning machines which have either self-contained condensing units or remote high sides. Practically all the installations use streamline fittings as described in Paragraph 388. Some special precautions are given in connection with certain controls. Air-conditioning evaporation pressures are quite high because the coils are operated at the relatively warm temperature of

50°F. to 55°F., although lower temperatures than these are sometimes used. This construction makes certain troubles very likely to occur. When the machine shuts off momentarily, due to the functioning of the controls, the refrigerant controls tend to open very rapidly, being of the thermostatic type, and tend to flood the coil, the suction line, and compressor with liquid refrigerant. This naturally decreases the efficiency of operation of the machine by frosting the suction line. A device consisting of an electric solenoid refrigerant valve must be put into the liquid line just ahead of the refrigerant control to remedy the condition. The electrical connections to this valve must be connected to the motor control in such a way that, when the compressor stops, this valve will close tight, preventing any more refrigerant from entering the cooling coil until the condensing unit starts operating again. Needless to say refrigerant leaks must be entirely eliminated in these installations because a leak in the cooling coil, for instance, will tend to distribute the refrigerant throughout the premises to be comfort-cooled. Special precautions should be taken by the installation man to remove condensation of moisture from parts of the unit. The tubing should be installed in such a manner that it will not drip into the room to be cooled, or allow any adjacent surfaces to condense moisture from the air.

392. MARINE INSTALLATIONS:

Three special features of refrigerating machines used for marine purposes are: (1) safety, (2) the difficulty of procuring non-corrosive cooling mediums, (3) the need for flexibility in the tubing or pipe installation. On the fresh water lakes such as Erie, Michigan, or Huron, no difficulties are encountered as to the types of refrigerators put on board except from the safety point of view. Many of the larger

boats use their regular electrical system for power for refrigeration and some use an auxiliary steam engine or a Diesel engine as motive power. A poisonous refrigerant or a severely irritating one is not recommended for marine installations for obvious reasons. Until recently carbon dioxide machines of the industrial class were used exclusively aboard ship although some applications of ammonia were made. The refrigerant Freon seems to be an ideal refrigerant for marine installations and is becoming quite popular as such. However, the use of ammonia on boats has increased rather remarkably, due, it seems, to the fact that the record of accidents from such a hazard have been almost negligible.

When making an installation on a boat, special care must be taken to insure that the tubing can stand the weaving of the boat in the rough seas. On salt-water bodies, the water-cooled condenser must be of special construction so that the corrosive sea water will not injure the water-carrying tubes. Tinned copper tubing will serve this purpose for a short time, but special alloys which resist corrosion are recommended.

393. SERVICING CONDENSING UNITS:

Condensing units come under two general divisions—water-cooled and air-cooled—and involve the compressor, the condenser, liquid receiver, the various motor controls, and water valves. The compressor itself may be tested for efficiency exactly as described in Chapter XI, but such things as "lack of refrigerant" presents new problems. An air-cooled condenser gives the same symptoms when there is a lack of refrigerant as those explained in Chapter XI, but the water-cooled parts present a quite different problem. Because of similar variations throughout the mechanism, the study is divided into individual parts of the condensing unit.

The condensing unit should be cleaned externally as thoroughly as possible, using rags and a non-inflammable cleaning fluid. The belts should be checked for alignment and tautness. If there is any decided pounding sound occurring regularly in the compressor, the customer should be informed of this, and a recommendation made that the compressor be overhauled as soon as possible. The amount of refrigerant in the system should be very carefully checked according to methods mentioned previously in this chapter. The water flow should be so adjusted that the temperature rise is more than 15° as the water goes through the condenser. The motor control should be inspected to determine whether it trips freely and whether the points, if any, are clean. Sandpaper of a fine grade is the only cleaning device recommended for these points.

394. SERVICING THE COMPRESSOR:

To test the compressor for efficiency, the service man may use the following methods:

1. Determine the vacuum that the compressor will develop by turning the suction service valve all the way in after installing a compound gauge in the gauge opening. Record the highest vacuum obtainable against whatever head pressure the machine has. Figure 147. Also record the time. If the compressor cannot produce a vacuum of greater than 20 inches of mercury against its own head pressure, it should be overhauled. After a vacuum has been drawn, the compressor should be stopped; if the vacuum decreases, it means that either the exhaust valves in the compressor are allowing the refrigerant to leak back into the crankcase, or that the crankshaft seal is leaking.

2. To determine if the exhaust valve is leaking, turn the discharge service valve all the way in after installing the

high pressure gauge in the gauge opening; then turn the compressor over very slowly by hand. If the exhaust valve is leaking, the head pressure as indicated by the high pressure gauge will fluctuate as the compressor turns over, but if it is holding, the head pressure will increase to a certain point where it will remain constant.

3. To determine whether or not the crankshaft seal is leaking, close the suction service valve, pump as high a vacuum as possible on the crankcase of the compressor, and with the discharge service valve and suction service valve turned all the way in, keep the compressor running. If a low side leak is in existence, the head pressure will gradually increase with the running of the compressor, indicating that gas or air is being drawn in on the low side of the compressor.

4. An intake valve leak is always indicated by the inability of the compressor to produce a high vacuum, but whatever vacuum is produced is maintained after the compressor is shut off provided the exhaust valve is holding.

395. SERVICING THE CONDENSER:

The troubles encountered in commercial condensers are: air in the system, too much refrigerant, not enough refrigerant, too much oil or a corroded interior. Whether the condenser is air- or water-cooled, too much refrigerant, too much oil, or a corroded interior of the condenser will produce an excessive head pressure. Air in the system will also produce this condition. To determine which one of these four causes is responsible for this condition, one must proceed as follows: Install the high pressure gauge in the discharge service valve gauge opening and determine what the head pressure is. Compare this pressure with what the pressure should be. The correct pressure may be determined by adding 30°F. to 35°F. to the room temperature, if it is an air-cooled condenser, to obtain the refrigerant temperature on the interior of the condenser. Using this corrected temperature, refer to the refrigerant charts (Figures 309, 310 and 312), for the correct head pressure. If the unit is water-cooled, one must add 20°F. to 25°F. to the temperature of the water just as it is leaving the condenser to obtain the refrigerant temperature. The correct head pressure is then obtained from the refrigerant chart as before. The unit must be running for these conditions to hold true. If the head pressure exceeds this value by more than 5 pounds, purge the system through the discharge service valve gauge opening for 10 to 15 seconds; then run the condensing unit again. To determine whether or not the trouble is excess refrigerant, or air in the system, stop the unit and purge as before for 15 to 20 seconds. If the pressure drops somewhat, it is air in the system. If the pressure does not drop, continue to purge the unit until that part of the condenser and liquid receiver which is full of liquid refrigerant becomes cold. This will quickly reveal the level of the refrigerant in the condenser and liquid receiver, and one may easily judge whether or not this is the correct amount. An excess amount of oil in a system is indicated by the erratic refrigeration obtained, and a continuous slugging or pumping of oil in the compressor, especially just as it starts after an off-part of the cycle. A corroded condenser is determined by noting the liquid line temperatures of the refrigerant. In case the amount of refrigerant is correct, and if the other troubles just mentioned are not prevalent in the system, a corroded condenser will produce a hot liquid line in an air-cooled system; also in a water-cooled condenser, it will produce a temperature in the condenser considerably above that to be expected. If all other possible causes of excessive head pressure are eliminated according to the above methods, a badly corroded condenser is probably the cause. Water-cooled con-

densers should not be placed in a location which may be subjected to freezing temperatures.

In the event a water-cooled condensing unit is to be shut down and perhaps subjected to below freezing temperatures, the condenser coils must be completely emptied of water. This may be done by blowing out the coils with air.

396. MOTOR CONTROL TROUBLES:

Three types of motor controls are used in commercial refrigeration, namely, the low side pressure motor control, the thermostatic motor control, and the high side safety motor control. The troubles encountered with these are:

1. Corroded points
2. A broken "Mercoid" bulb
3. Out-of-adjustment
4. Corroded or broken operating springs
5. Out-of-level
6. Leaky bellows

Motor controls normally function year in and year out without giving trouble, but in cases such as overloading the unit, the resultant short cycling will very rapidly deteriorate the breaker points in the control, or will so overload the "Mercoid" that it will crack and be destroyed. Corrosion of the points may be remedied by cleaning with very fine sandpaper (emery cloth must not be used). A broken Mercoid bulb must be replaced.

An out-of-adjustment switch is often the result of tampering, and these causes of trouble are often difficult to overcome. A pressure control may be easily checked by installing a compound gauge in the suction service valve; use the compressor as a vacuum and pressure pump and check the cut-in and cut-out points. Three different methods may be employed to build up a pressure in the crankcase after the compressor is run to the cut-out point of the control: (1) the suction line may be cracked open again; (2) a by-pass may

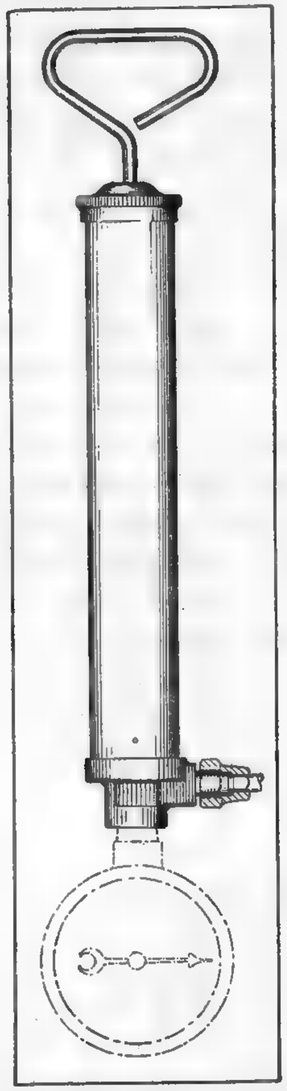


Fig. 295. A hand vacuum pump used for regulating motor controls
(Courtesy of: American Injector Company)

be run from the discharge service valve of the compressor to the suction service valve; (3) one may use a refrigerant

service drum containing the same kind of refrigerant attached to the suction service valve. Many service men carry a hand vacuum pump in their tool kit for the purpose of testing controls. Figure 295. This tool enables a very rapid check of the pressure control. A thermostatic motor control is more difficult to reset; the only approved method is to use an ice bath and thermometer. The control may then be set to cut in or out at any temperature desired. See Paragraph 252.

The high pressure motor control presents very few difficulties because it is adjusted to work only under extreme conditions. The most common troubles encountered are the occurrence of leaks in the bellows, or at the joints of the controls. Occasionally, however, one will find that this control is short cycling the refrigerating mechanism, and this short cycling is due to excessive head pressure. To check a high pressure motor control element, connect it to the discharge service valve of the compressor along with a high pressure gauge, and turn the discharge service valve all the way in. On running the compressor a head pressure will be produced sufficient to cut-out the control; the high pressure gauge will record the pressure at which the cutting out takes place.

397. METHODS OF REPAIRING THE LIQUID RECEIVER:

The liquid receivers used in most commercial systems serve as refrigerant storage tanks and are usually constructed of a steel shell welded or brazed at the joints. The simple liquid receiver, which has a cooling coil built into it, sometimes develops leaks. Because of corrosive action of the water and refrigerant under certain conditions, the copper tubing which is used to carry the water eventually corrodes

through; the resultant leak forces the refrigerant from the system into the cooling water. A leak of this kind is detected by the release of fumes at the water drain. Also, leaks occasionally occur at the joints where the water-cooling coil is attached at the liquid receiver and may be due to abuse or to corrosive action. In such a case, the condenser should be replaced with a new one. If new parts are not obtainable for the machine, a fairly satisfactory repair may be made as follows: The water tubing, if eaten through within the liquid receiver, must be removed. The liquid receiver is mounted on the lathe and the end of the receiver is cut open. This permits one to remove the old water coil and to put a new one in. The new one is to have a length of tubing equivalent to the one removed, or the capacity of the condenser will be reduced materially. The new coil is usually made up by winding it on a drum mounted on a lathe. The tubing is then put in the liquid receiver and the joints are preferably brazed, but they may be soldered. The end of the liquid receiver that was removed may now be replaced after the interior of the receiver has been cleaned thoroughly, using carbon tetrachloride, and the joint is either soldered, brazed or acetylene welded.

398. CARE OF SERVICE VALVES:

Service valves on commercial installations must be kept in very good condition because they are used much more frequently than those on a domestic unit. Three things may be noted which will assure good service valve life: (1) fitting the wrench to the valve stem, (2) maintaining the packing so that the service valve will not leak, (3) oil the threads of the gauge connection each time gauges are used. Occasionally after a certain period of use these service valves have to be replaced. After gauges have been mounted in the gauge

opening of the valve a number of times, the pipe threads in the valve gauge openings become worn and leak at this point. However, if the fittings inserted in these gauge openings are given a thin coat of solder, this trouble will be eliminated. One of the most frequent valve troubles is the breaking of the valve stem because of the stem sticking in the valve body. Most valves are made with a drop-forged brass body and a steel valve stem; therefore if one will heat the service valve with a torch, the difference in expansion qualities of the two metals will loosen the stem from the body and make it easy to turn. If one does this and at the same time taps the valve stem lightly with a hammer, there will be no difficulty in turning the valve stem.

399. SERVICING WATER VALVES:

Water-cooled condensers require attention frequently because of incorrect water flow. This trouble will usually be due to the water valve or the screen. See Figures 246 to 251 for details of construction of these valves.

400. RESTRICTED WATER FLOW:

Common troubles encountered with water valves if the water flow is too little are as follows:

1. A leaky valve
2. A clogged screen
3. A chattering valve
4. The adjustment of the valve turned out too far
5. A sediment-bound valve
6. A leaky bellows

In addition to these troubles, the water-cooling system may present the following difficulties: Many of the water-cooled systems use a 2-foot length of rubber hose connected between the water pipe running along the wall and the con-

densing unit water lines in order to eliminate transmitting the condenser vibration into the plumbing system of the building, and also to eliminate breakage of tubes from this vibration. The cold water inlet hose connection presents no difficulties and this hose will ordinarily give many years of service. However, as the water circulates through the condenser and cylinder head of the compressor, it sometimes be-

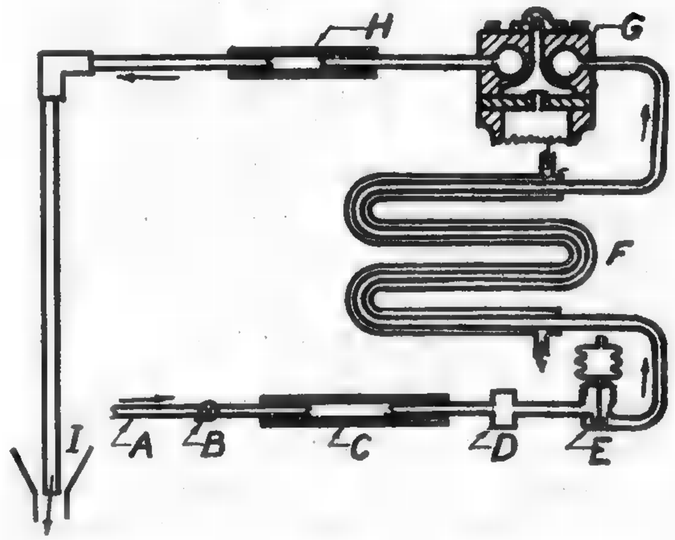


Fig. 296. A typical water circuit for a water-cooled condensing unit
A. Water-in; B. Hand valve; C. Rubber hose; D. Strainer; E. Automatic water valve; F. Condenser; G. Water-cooled cylinder head; H. Rubber hose; I. Open drain

comes quite warm. This warm water, as it passes through the outlet hose connection, tends to deteriorate the inner rubber of the hose, resulting in a blistering of its inner wall. This will eventually clog the hose and restrict or stop the flow of water through the condenser. Occasionally, someone will partially or completely shut off the water supply by closing the hand-operated valve installed in the system. The two most common complaints which indicate troubles with the

water circulation are a lack of cooling in the condensing unit and too great a consumption of water. If the water circulation is stopped, the refrigerating system will start to short cycle, due to the functioning of the high pressure switch since these systems are always provided with a high pressure safety motor control for this purpose. As the head pressure of the machine builds up due to a lack of cooling, a pressure is soon reached at which this control will open a switch stopping the motor. As soon as the motor is stopped, the head pressure drops rapidly, permitting the high pressure control to turn the motor on again. This short cycling will continue indefinitely unless the trouble is remedied. Such a condition is a severe strain on the motor and will not give satisfactory refrigeration. See Figure 296 for a diagram of a typical water circuit.

401. TOO GREAT A WATER FLOW:

Too great a water flow will give very satisfactory refrigeration, but the amount of water consumed will be in excess of that needed and greatly increase the cost of operation. The three things which may cause too great a water flow are:

1. Too high a water pressure
2. A leaky water valve
3. A water valve out of adjustment in such a way as to hold a valve too far open

The condition of too high a water pressure is seldom encountered unless the water supply pressure is uncontrolled. If encountered in one machine, it will perhaps be true for all the machines in that locality. To determine whether the condition is due to a leaky valve or to a valve adjusted open too far, one may best check this by asking questions of the proprietor as to whether anyone has been working on the machine. If the machine has not been tampered with, and

the trouble has just begun to make itself evident, one may usually lay the trouble to a leaky water valve.

402. TRACING WATER CIRCUIT TROUBLES:

The principal problem in this latter case is to determine whether the water valve is giving the trouble or if it is caused by some other part of the water circulating system. To locate the exact source of the trouble, one may disconnect the joints where the hose is fastened to the rest of the system. By disconnecting the exhaust water hose from the machine unit, one can readily determine whether the water is flowing as far as this point. If the water is coming as far as this point, one should reseal this connection and disconnect the other end of the hose from the wall pipe. If the water does not flow up to this point, the trouble is in the exhaust rubber hose of the system. If the water does not flow up to this hose, one should determine whether the water is coming as far as the water valve by disconnecting the rubber hose used as the inlet connection. If the water flows through this hose, the only sources of trouble are the water valve and the condenser proper. To check this, reseal the inlet rubber hose from this system and disconnect the water valve from the condenser. If the water flows through the water valve, but does not go through the condenser, the trouble is a major one necessitating a replacement or cleaning of the condenser water tubes. However, if the water does not flow through the water valve, it must be disconnected from the system and repaired or replaced.

403. REMOVING A WATER VALVE:

To remove an electrical water valve from the system, one must open the hand switch that controls the circuit to the motor and remove the water valve wires from the motor cir-

cuit. Since these wires are usually soldered and taped, it will be necessary to cut them. Before disconnecting the water valve from the water system, the water supply must be shut off at the hand valve for that purpose. If the serviceman does not have a replacement valve on hand, the water system may be temporarily connected without a water valve and the water flow regulated with the hand shut-off valve.

A pressure operated water valve is somewhat difficult to remove from the system because the valve is connected to the high pressure side of the condensing unit. The pressure tube for these valves is usually connected into the cylinder head of the compressor, although some manufacturers connect this tube into the liquid line of the unit. A hand shut-off valve for this tube is sometimes provided, and if so, the removing of the valve is very simple. In case the tube is connected to the cylinder head of the compressor, the following is the best procedure to removing it:

1. Install the compound gauge in the suction service valve gauge opening.

2. Turn the suction service valve all the way in.

3. In case the refrigerant is methyl chloride or Freon, run the compressor until the pressure in the crankcase registers 0 pound per square inch. If the system uses sulphur dioxide, one must evacuate the crankcase and then balance the pressure by cracking the suction service valve.

NOTE: Be very careful of oil pumping which sometimes will occur before the pressure of 0 pound per square inch can be reached with Freon or methyl chloride. This oil pumping always occurs when a sulphur dioxide unit is evacuated to a 10-inch or 12-inch vacuum.

4. Heat the water valve line and the water valve bellows carefully with a blow torch for 3 or 4 minutes until both of these become quite warm to the hand. This operation will

drive the liquid refrigerant, which has condensed in this tube and valve, back into the condensing unit, leaving only a small quantity of high pressure gas in this tube.

5. Turn the discharge service valve all the way in.

6. Clean the joints to be opened.

7. Disconnect the pressure tube from the water valve.

8. Plug the refrigerant pressure tubing openings immediately.

9. Heat the water valve again very gently, especially if it is a sulphur dioxide system, for often a quantity of liquid refrigerant becomes oil bound within this bellows chamber, and releases with explosive force a few minutes after the valve is opened to the atmosphere. NOTE: Be very careful not to point these refrigerant openings toward anyone because of the danger of being hit by this refrigerant.

10. Shut off the water supply.

11. Disconnect the water valve from the water line and replace it with a good one or connect the water lines directly. The water valve is now ready to be dismantled and repaired.

404. REPAIRING A WATER VALVE:

To completely overhaul a water valve, in addition to cleaning it, which may best be done with wire brushes, the valve and valve seat must be repaired. The valve seat, which is made of brass in most cases, may be lapped in a manner similar to lapping a compressor valve seat. The valve proper usually consists of fiber, rubber, or bakelite material and it should be replaced with a new part. In cases of emergency, however, this valve may be trued up by using a fine grade of sandpaper backed up by a level surface. Occasionally, where the valve actuating stem passes into the valve body proper, a packing gland is used to seal this joint. This packing is the typical asbestos, graphite, and lead packing. If the

packing nut has been turned all the way down, this packing should be replaced.

405 ADJUSTING A WATER VALVE:

After cleaning and repairing a water valve, it should be tested and adjusted before being replaced in service. If the maximum temperature of the water supply is 75°F. the valve should be adjusted to open at the following pressures: 48 pounds per square inch for sulphur dioxide; 76 pounds per square inch for methyl chloride; 94 pounds per square inch for Freon; 152 pounds per square inch for ammonia.

Refrigerant	Water in Temperature °F										
	50	55	[illegible]	65	70	75	80	85	90	95	100
Sulphur dioxide	26.5	30	34.5	38	43	47.5	53	68	65	70	77
Methyl chloride	47	52	57	63	70	76	82.5	89	96	103	111
Freon	56	62	68	74	80	87	93	101	108	117	125
Ammonia	98	108	119	130	140.5	152	164	177	191	205	220

Fig. 297. A table of water valve pressure settings

If the water-in temperature is different from this, one may adjust the valve to its correct opening pressure using the following rule: for every 5° change in water temperature, change the opening pressure of the valve 6 pounds per square inch for sulphur dioxide, 5 pounds per square inch for methyl chloride, 7 pounds per square inch for Freon, and 12 pounds per square inch for ammonia. For example, if the water temperature in the methyl chloride system is 65°F. instead of 75°, the opening pressure of the water valve should be lowered to 64 pounds per square inch. Figure 297. A valve should also be tested for leaks at the same time that it is being adjusted. This may be done by connecting an air pressure line to one of the water openings of the valve. In order to adjust and test the pressure operating bellows, which controls the water flow, connect another air line and a pressure gauge to this fitting. No air should flow through the water valve until the correct control bellows pressure has been reached. Necessary adjustments may be made to obtain this condition.

406. CHECKING THE REFRIGERANT CHARGE:

One of the most detrimental conditions which may occur in a refrigerating system is to operate the refrigerator without sufficient refrigerant. It results in abuse to all of the valves in the unit and also usually results in continuous motor operation. Several methods may be used to indicate whether or not a refrigerator has an adequate supply of refrigerant demanded for satisfactory operation.

In a low side float system the lack of refrigerant usually shows up at the most remote coil, or the coil which is the greatest vertical distance from the liquid receiver. If the refrigerant is low, this coil will not have enough liquid refrigerant in it to close the float valve. As a result the coil will make a continuous hissing sound while the refrigerant gas flows through it. This condition will be accompanied by a warm liquid line which will be several degrees warmer than the suction line. This may be easily checked by feeling of the two lines at the place where they are attached to the coil.

A dry or expansion valve system is much more difficult to check for quantity of refrigerant. The first indication of insufficient refrigerant may be obtained from the appearance of the expansion valve body. Under normal conditions the body of the valve frosts over evenly as far back as the liquid line nut; but in case the system has insufficient refrigerant, the expansion valve body adjacent to the liquid line will not frost.

A common method of checking for quantity of refrigerant is to check the quantity actually in the liquid receiver and condenser. One way to do this is to determine the high side head pressure. If the unit is air-cooled, the head pressures for the system should correspond to refrigerant temperatures 30°F. to 35°F. higher than the room temperature while the unit is running. If the unit is water-cooled, the head pressure should correspond to refrigerant temperatures approximately 25°F. higher than the temperature of the water leaving the condenser. The temperature of the water in this case should be checked at the point where it leaves the condenser and not at the end of a long drain pipe. If the head pressure, as indicated on the gauge, is below normal as much as 10 pounds per square inch it indicates a lack of refrigerant.

Another method is to mount a glass sight gauge in the liquid line and note if there are any gas bubbles going up the liquid line. Bubbles indicate insufficient refrigerant. A head pressure of 65 pounds per square inch or more must be used because at low head pressure bubbles may appear regardless of the amount of refrigerant in the system. If no bubbles appear in the sight gauge at the above pressures, the machine has sufficient refrigerant.

Some machines are equipped with refrigerant liquid level indicators such as pet cocks mounted in the side of the liquid receiver at definite heights. If the pet cock is opened and liquid refrigerant comes out, the level of the refrigerant is at least so high. Two pet cocks are usually provided and gas should come from the top one, while liquid refrigerant should come from the lower one if they are opened.

The Frigidaire Corporation has designed a clever liquid level detector which is in use in this company's commercial high pressure sides of 1/3 H.P. and over. A float to which is attached a permanent magnet is placed in the liquid receiver. A well is built into the wall of the liquid receiver in which a gauge may be inserted by the service man. The permanent magnet, attached to the float on the inside of the receiver, operates the gauge needle to indicate the corresponding level of the refrigerant. The gauge is usually calibrated by gauge readings of ¼, ½, and ¾ full, etc. Some companies use a glass sight gauge attached to the liquid receiver to indicate the liquid refrigerant level.

In the liquid receiver type of water-cooled unit in which the water coils are located within the receiver, the amount of refrigerant within the system may be checked by determining the temperature differences of the receiver. The division point between the part of the tank filled with hot gas and the part filled with cold refrigerant will be indicated by a temperature difference which may be easily found by feeling of the tank with the hand.

Another method of determining the quantity of liquid refrigerant in the liquid receiver consists of turning off the cooling water to the condenser, allowing the compressor to operate. If the liquid line warms up quickly it is an indication of insufficient refrigerant. Also it may be noted in this connection that the head pressure rises after the water is shut off. If the compressor is now stopped and the head pressure drops rapidly, it is another indication of a small amount of liquid refrigerant in the liquid receiver.

Still another method of checking for the quantity of liquid refrigerant consists in shutting the machine down and purging the liquid receiver. The boiling of the refrigerant in the liquid receiver, when the pressure is reduced, will cause the part of the receiver that is filled with liquid to get very cold and frost over. This method is rather expensive and should only be used as a last resort for it wastes considerable refrigerant. If any system is found to lack refrigerant, this must be due to a leak of some kind in the equipment. A very

careful check should be made of all joints and parts that could possibly leak before the unit is recharged and put into service.

407. CHARGING A COMMERCIAL SYSTEM:

Charging commercial systems is very similar to charging domestic machines with the exception that practically all the charging in commercial work is done into the high pressure side, while most domestic charging is into the low side. To charge a commercial system the storage cylinder should be attached to the gauge opening in the discharge service valve and then inverted. If the unit is water-cooled, the pressure in the liquid received with the water flowing will be sufficiently below that of the pressure in the cylinder to permit opening of the two valves after the charging line has been purged. The pressure difference will empty the cylinder into the system. If the unit is air-cooled, the pressure in the refrigerant drum will have to be increased. This may be done by using the compressor to pump gaseous refrigerant into the drum and increase its pressure. In detail this method is as follows:

1. Connect the refrigerant cylinder to the discharge service valve along with a high pressure gauge
2. Run the compressor with the discharge service valve turned all the way in until a pressure of 125 to 135 pounds is built up in the cylinder
3. Stop the compressor
4. Invert the refrigerant drum
5. Turn the discharge service valve part way out

The high pressure on the surface of the refrigerant in the drum will force the liquid into the system. While the liquid is flowing into the high side, a gurgling sound may be heard. If this sound ceases abruptly, it means that the cylinder has been emptied. The amount of refrigerant to be put into a

system that is being serviced for a lack of sufficient refrigerant must be governed by the service man's knowledge concerning the size of the system, the apparent amount of refrigerant in the system, and the kind of refrigerant used. See Figure 298.

408. DISCHARGING THE SYSTEM:

As recommended in Paragraph 197, whenever it is necessary to discharge a system for repair purposes the refrigerant, if not in excessive quantity, should be discarded, using the method of purging it out of the nearest window by means of

	Sulphur Dioxide		Methyl Chloride		Freon	
	Flooded	Dry	Flooded	Dry	Flooded	Dry
½ H.P. unit....	5	2½	3	1½	3	1½
1 H.P. unit....	10	5	6	3	6	3
1½ H.P. unit....	15	7½	9	4½	9	4½
2 H.P. unit....	20	10	12	6	12	6

Fig. 298. A table of amounts of refrigerant to be added to commercial systems. The approximate maximum amount of refrigerant to be put in the unit at one time when it is low on refrigerant

¼-inch copper line; make sure that the oil in the refrigerant will not harm any surrounding property. This method cannot be used for ammonia or sulphur dioxide because of the odors and they may best be purged down the open sewer along with a large quantity of running water. Small quantities of sulphur dioxide may be neutralized with lye. If the refrigerant is to be put back into the same machine, or if facilities are available for distilling it, it may be temporarily stored in a refrigerant drum. One must remember that this refrigerant will always have an oil charge. Some large companies save all refrigerant, redistill, and process it for further use. This amounts to a considerable saving when great

quantities of refrigerant are used. See Paragraph 256 for methods of distilling refrigerant.

409. USE OF DEHYDRATORS, DRYERS, AND NEUTRALIZERS:

Many troubles in refrigerating systems may be traced to the presence of moisture in the system. Moisture in the presence of sulphur dioxide builds up an acidic condition, which corrodes the compressor parts and quickly ruins the entire system. With some of the other refrigerants, the moisture combines with them so as to form slight acids which although

Fig. 299. A typical dehydrator showing the location of the felt and screens. Note the bolted construction to facilitate charging. The screens used are 200 mesh

(Courtesy of: Kerotest Mfg. Company)

very slow acting eventually are a source of trouble. With Freon, methyl chloride, iso-butane, Carrene, and some others, moisture in the system freezes at the refrigerant control orifice, eventually clogging it. If immediate action is taken to remove all moisture, many troubles may be eliminated.

The use of a dehydrator is the best method for removing any moisture that may be in a refrigeration system. The usual dehydrator consists of a large sized cartridge charged with some moisture-absorbing chemical and connected in the liquid line. Figure 299. The chemicals used may be calcium oxide, calcium chloride, activated alumina, zinc moss, or

silica gel. Calcium chloride because of its low cost is the most popular moisture absorber used. Care must be taken in using dehydrators filled with calcium chloride to prevent the circulation of any of this chemical through the system. To prevent this the outlet end of the dryer should be equipped with a very fine mesh screen in addition to at least ¼-inch thickness of felt. If there is more moisture in a system than a single calcium chloride dehydrator has ability to absorb, this chemical will be dissolved by the moisture and circulate through the system. This action will cause excessive wear and will clog the screens. For this reason, the charge of calcium chloride should be greatly in excess of what is needed; also the dryer should never be allowed to remain in the system more than 24 hours. If the system is suspected of having large quantities of moisture, the dryer must be removed and charged again after an hour or so. The calcium chloride used in dehydrators must be chemically pure and stored in an air-tight container, otherwise it will absorb moisture from the air and be useless in a dehydrator.

In sulphur dioxide systems any moisture in the system produces sulphurous acid, and moisture-absorbing chemicals or dehydrators would be of no use in a system of this kind. Therefore, one cannot use dehydrators or dryers charged with calcium chloride in a sulphur dioxide system. However, a neutralizer may be used in place of a dryer. Neutralizers consist of a cartridge similar in construction to a dehydrator, but charged with a chemical that will react with the acids in the system. The chemical used must be a very powerful reagent in order to neutralize thoroughly any acid condition. Zinc moss or activated alumina is very good for this purpose. These neutralizers may be placed in the liquid line, although it is best to place them in the suction line in order to keep sulphurous acid out of the compressor. If located in the suction line, the cross sectional area must be great enough

to permit the gases to flow to the compressor without too great a restriction. This requires rather a large neutralizer for this location.

410. SERVICING THE MOTOR:

Motors used on commercial units usually vary in size from ½ H.P. to 2 H.P., with 1 H.P. motors being by far the most popular. Air-conditioning systems require larger motors than this—often 10 H.P. or more. These motors are connected to either 110-220 volt single-phase or to three-phase lines. The most popular voltage for the medium sized commercial motor is 220 volts single phase. To test the motor, it should be disconnected from the compressor and run without any load imposed upon it. The sound of the motor is very indicative of any trouble. Under normal conditions a motor will emit a steady low hum, but in case of worn bearings, rubbing armatures, dry bearings, lack of voltage, etc., erratic beats will be heard in the humming, and the armature may chatter. If one is doubtful as to the motor's condition, it may be thoroughly checked as suggested in Chapter VIII. With the motor running, make sure that the armature position is between the two extremes of the armature end play. If the armature operates against one extreme of the end play, it means that it is trying to assume its magnetic center and in not being able to do so is running inefficiently. The end play should never exceed 1/16-inch and may be adjusted by using fiber washers which are obtainable at any electrical supply house. Adequate lubrication of the motor bearings is absolutely necessary, and the amount of oil in them should be carefully checked. Too much oil is just as detrimental as not enough. Most motors are equipped with overflow openings which eliminate most of the danger of too much oil. Bearing temperatures are best checked with a thermometer.

The motor should occasionally be cleaned thoroughly, using gasoline or carbon tetrachloride. No dust, dirt, or grease accumulation should be left within the motor or on the exterior of it. Commutators and brushes, if used, should be cleaned and they must make good contact with each other. The brush throw-out mechanism should be free. The brush releasing mechanism of small motors may be checked by mounting a V-belt on the motor pulley and imposing a load on the motor by pulling on the other end of the belt. A torque stand is naturally the best means of determining the real capacity of a motor. See Paragraph 248.

411. SERVICING MULTIPLE FLOODED COILS:

The repair of low side floats is similar to that of the single unit refrigerators discussed in Chapter XI, but locating the trouble and dismantling and assembling of the unit differs somewhat from the single unit practice. Gauges cannot be used to investigate individual coil troubles on multiple installations. Therefore, one must use ordinary observation to determine the trouble. A continuous hissing sound in the cooling coil is always an indication of coil trouble and may be due to the following causes: (1) a leaky needle, (2) a lack of refrigerant, (3) a float out of calibration, (4) the cooling coil not being level, (5) a leaky float ball. This hissing sound is very distinctive if there is a lack of refrigerant and, in addition, the liquid line is considerably warmer than the suction line at the cooling coil. This may be determined by putting one's hand over the two lines just as they are going into the cooling coil. The temperature difference will be noted at once. Also, the suction line, although cold, will never frost or sweat if there is a lack of refrigerant. If the needle and seat are leaking, the hissing sound is not so distinctive and may be classified more as a gurgling sound. Also, the suction

line will likely frost back to the opening in the cabinet wall and sometimes all the way back to the compressor. This frosting under normal conditions should never be more than 6 inches to 8 inches back along the suction line.

A low side float coil out-of-level may be very easily checked with a spirit level. An out-of-calibration float and a leaky float ball are rather difficult to check and necessitate dismantling the cooling coil to learn the source of the trouble. A float which is calibrated so that the refrigerant level is too low when the needle closes will not give the above sound, but will be indicated by a poor frost surface on the coil and inadequate box temperatures; it will tend to become oil bound, since this condition permits an extra deep layer of oil to form on the top of the refrigerant.

In case of a lack of refrigerant, the coil farthest from the condensing unit virtually will be the one to show lack of refrigerant first. Another way to check up as to what trouble is occurring in the coil is to loosen the cooling coil from its hanger and rock it back and forth. If it has an out-of-calibration float or a slight lack of refrigerant, one will be able to hear the hissing sound stop for short periods of time as the liquid refrigerant moves back and forth in the chamber. If it is a leaky needle, the noise will not change. If the needle is leaking, or one of the other troubles is existent, one way to determine it is to shut off the liquid line valve (normally the one mounted right on the cooling coil). Then allow the condensing unit to run for several minutes; this will lower the float more than usual. Next, quickly open the valve, permitting a rush of liquid refrigerant to wash past the orifice opening; if a piece of dirt has lodged between the needle and its seat this will be immediately washed away and the sound of hissing or gurgling will stop momentarily, telling that the trouble has been eliminated.

To dismantle the cooling coil, in case the necessity arises, the procedure varies depending upon the low side pressure that the unit is operating under. A common servicing policy, if a leaky float needle is discovered, is to close the liquid line valve and leave the coil for a day. During this time the operation of the condensing unit gradually pumps the refrigerant out of the bad coil, and continues to furnish refrigerant for the other cooling coils in the systems. The users of the cabinet should be warned that refrigeration will not be continued until the coil is repaired. After the above period of time, a replacement float mechanism should be installed in the coil. It is not recommended to repair the unit on the job. Nor is it recommended to keep the float chamber open for any length of time. The coil is now all pumped down, and the next operation is to balance the pressures and isolate the coil. As mentioned above, the balance depends upon the low side pressures in the system. In many installations this pressure will be found to be very close to atmospheric; in the case of Freon or methyl chloride, the pressures are atmospheric or above. If the pressures are atmospheric or above it, the service man simply turns off the nearest suction line valve which will isolate the cooling coil from the rest of the system. After thoroughly cleaning all of the joints and drying them, the unit is ready for dismantling. However, if the pressures are below atmospheric, as with sulphur dioxide, the following procedure must be followed. The pressures throughout the low side of the system are the same; therefore, if the unit is running at 5 inches to 15 inches of vacuum, the service man must stop the unit when the compound gauge on the condensing unit reads 0 pounds per square inch, close the nearest suction line valve, and start the unit again.

There is always a quantity of oil in these low side float coils, and it is important when opening the chambers to

guard against any chance of the oil flowing out of the coil. To avoid the possibility of oil escaping, loosen the hanger bolts and tilt the coil so that the front end is lifted; this will eliminate this source of embarrassment. However, this leads to the difficulty of not being able to determine whether or not the cooling coil has too much oil in it. Unless the coil has been showing signs of oil binding, none of the oil should be taken out. A certain amount of oil is required for the correct operation of these units. The exchange of float mechanisms should be done as rapidly as possible and a new lead gasket should be used. When tightening the cap screws on the cooling unit header, extreme care should be taken to tighten them evenly. The best system to follow in tightening these screws is to skip each alternate screw and go around the header, tightening each screw a little at a time. Only experience can tell one how firmly to tighten these screws. As mentioned before, always use cadmium plated or Monel metal cap screws.

412. SERVICING CLOGGED SCREENS:

A very common trouble with multiple float systems is the clogging of the screen located at each individual coil. This screen is located in different places on different cooling coils. One low side float construction has the liquid line valve bolted on the header, and the screen is inserted in a little pocket between the liquid line service valve and the header. If a service call is made and it is found that all cooling coils except one connected to a multiple system are operating O.K., and this one coil is not giving any refrigeration whatsoever, the following procedure is recommended. The trouble may be due to one of three things, either the needle is stuck closed, the screen is clogged, or the float is completely oil bound.

A completely oil bound float may be detected by rocking the cooling coil; the needle will open momentarily during this procedure. If it is a stuck-shut needle, the orifice may be broken open very easily by tapping the header lightly. If neither of these methods determine the trouble, it is very probable that a clogged screen is the cause of the trouble. Figure 300. In the Kelvinator or Norge multiple low side

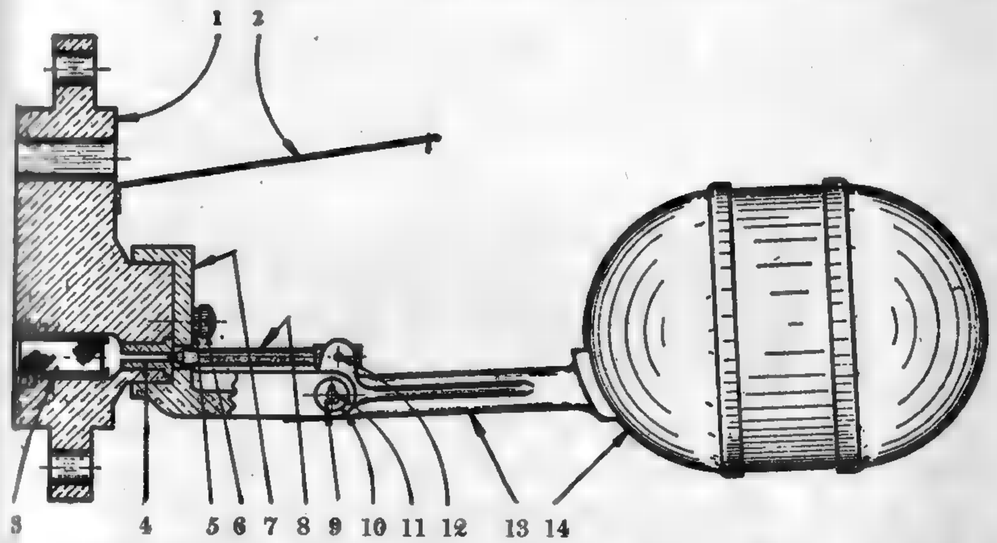


Fig. 300. A Kelvinator low side float mechanism showing the location of the screen.

1. Header; 2. Baffle; 3. Screen; 4. Valve seat; 5. Valve spring screw; 6. Bracket screw; 7. Bracket; 8. Valve; 9. Arm stop; 10. Valve spring; 11. Arm pin; 12. Valve pin; 13. Arm; 14. Float

(Courtesy of: Kelvinator Sales Corporation)

float systems, one must turn the liquid line service valve all the way in after loosening the packing nut. Then determine if the low side pressure is near atmospheric by putting a compound gauge on the condensing unit. If it is, the cooling coil is usually evacuated before the serviceman arrives on the premises; this is indicated by a warm cooling coil. Close the suction line valve and, after cleaning and drying the joint

between the liquid line service valve and the header, this valve may be unbolted. When the connection (a gasketed one) is opened, a little liquid refrigerant may escape, but this is readily neutralized with ammonia fumes. The screen is located at this point and is easily accessible to be replaced or to be cleaned. The recommended service practice is to carry several replacement screens and replace the clogged screen with a new one.

The screen in the Frigidaire low side floats is soldered into a fitting which in turn is mounted between the liquid line and the liquid line service valve. Figure 301. To remove this

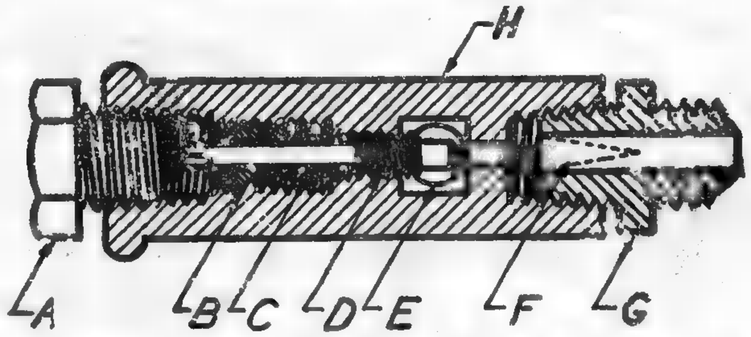


Fig. 301. A screen mounted in the inlet of the header liquid line valve
A. Plug; B. Packing nut; C. Packing; D. Valve stem; E. Opening to float; F. Screen; G. Liquid line fitting; H. Valve body

screen, the following procedure may be used. Since the screen is clogged, the refrigerant in the liquid line cannot be removed by evacuating it; but it may be removed by heating the liquid line with a torch. This heating should continue from the coil to the nearest shut-off valve back along the liquid line. The valve on the cooling coil header should be closed during this heating. This will drive the high pressure liquid refrigerant back into the main liquid line, leaving only gas. Shut off the valve located at the junction of these two lines. Now disconnect the liquid line nut from the liquid line valve on the coil header, after cleaning and drying it. As the liquid line is

disconnected from this fitting there will be a surge of high pressure gas out of this line; but this cannot be helped unless a very tedious program of removing all the refrigerant from the complete liquid line system is followed. The screen fitting may now be removed from the valve and cleaned or replaced.

Upon assembling the coil after repairing the trouble, proceed as follows: Open the two liquid line valves after the unit has been assembled and then carefully test for leaks. When starting a coil in this case, the serviceman should always wait until he hears the float valve stop the flow of refrigerant. This policy will save many call-backs in case the needle is leaky. The Kelvinator and Norge low side floats, when opened to remove a screen, permit a slow seepage of air into the cooling coil through the needle orifice opening. This amount is negligible if the unit is assembled immediately. In this case the procedure is similar to starting up a Frigidaire float coil. However, if the coil has been left open for a number of hours, the coil should be purged of air by loosening the suction service valve from the coil header and then cracking the liquid line valve. The resultant surge of gas will remove most of the air from the coil. Needless to say when reassembling the Kelvinator unit, a new gasket should be used and the two gasket surfaces should be perfectly clean and smooth. A scraper made from an old flat file is one of the best tools for removing the old gasket. If possible, the serviceman should put a little refrigerant oil on the new gasket before installing it. Never use other than Monel or extra heavy cadmium plated bolts and cap screws on cooling coils. Always test for leaks.

613. SERVICING DRY MULTIPLE COILS:

Dry multiple systems which use the thermostatic, expansion-valve, refrigerant control have troubles and the symptoms

may be similar to the low side float troubles. The same difficulties of servicing are encountered with these coils because of the number of coils connected to one condensing unit. The serviceman can only check the individual coils by the appearance of the coil, by the sound, and by the temperature of the expansion valve. If the coil is frosting back so that the suction line is frosted, it may be due to the following troubles: the needle may be leaking; the control may be adjusted for too high a suction pressure; the power element may be at-

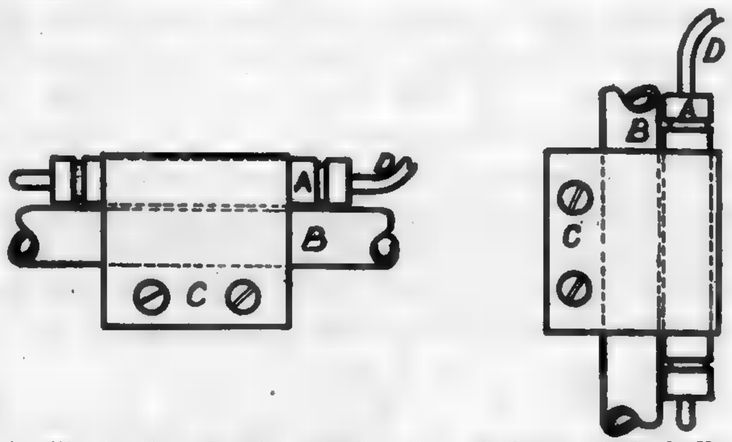


Fig. 302. An illustration showing the location of thermostatic bulbs on suction lines to obtain constant operation
A. Thermostatic bulb; B. Suction line; C. Clamping bracket; D. Capillary tube; E. Bracket machine screws

tached loosely to the suction line; the power element may be located in too warm a position; moisture may have condensed and frozen on the exterior of the bellows, keeping the needle open; also dirt in the system may be holding the valve open. To determine which of these troubles is the one responsible for the faulty operation is a difficult task, and the best method is a process of elimination. The location of the power element may be easily checked and its attachment to the suction line noted. It is recommended that the thermostatic bulb be placed on top of the suction line rather than beside

or below it in order that the liquid in the bulb will make good thermal contact with the suction line. A thermostatic control in which the adjustment has been tampered with is very rare and one may usually depend upon customers not trying to set them; therefore, one should not attempt to readjust the control at first, but rather to check for the other troubles. Leaky needles or out-of-adjustment valves cannot be repaired satisfactorily on the premises. The serviceman should remove a faulty expansion valve and replace it with one that is known to be in good condition. The troublesome valve may then be checked in the shop which should be equipped for this purpose and the trouble accurately determined. If it becomes necessary to dismantle a thermostatic expansion valve, the thermostatic element should be removed as a complete assembly and not taken apart. The thermostatic element is charged with refrigerant and the power element bellows is under considerable pressure at normal temperatures. In the assembled condition this pressure is counteracted by springs or by the expansion valve diaphragm pressure. If dismantled and the power element is free to act the pressure may burst the power element or at least extend it so far that its accuracy will be destroyed. If the thermostatic bulb is placed in an ice and salt solution and its temperature brought low enough, the power element may then be safely dismantled.

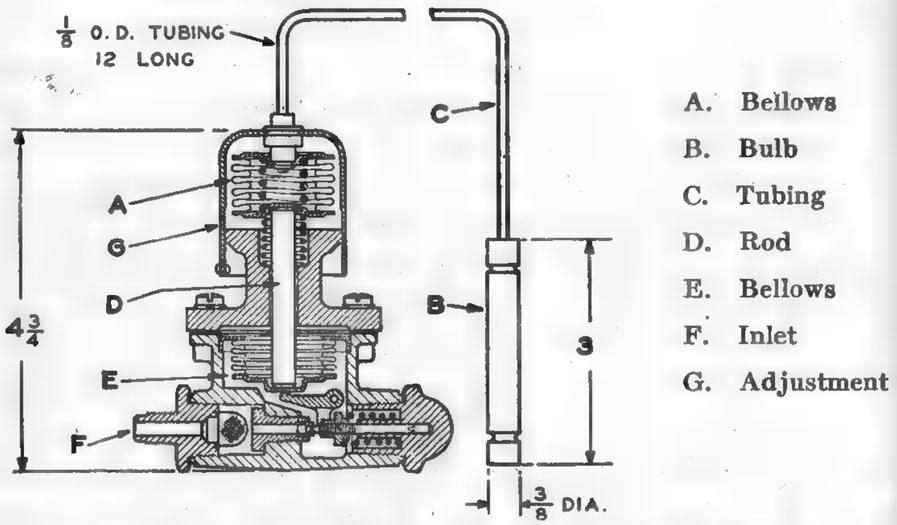
A starved coil, that is, one that is giving very poor box temperatures and the coil itself is frosting very unevenly or not sweating properly, may be due to the following:

1. A clogged screen in the expansion valve which may give no refrigeration whatsoever
2. A loss of refrigerant from the power element in the expansion valve will give very erratic refrigeration
3. Moisture in the system which may periodically give

good refrigeration and then none whatever, as the moisture will freeze in the orifice to the expansion valve and close it up

4. A stuck-shut needle, although this is a very rare occurrence

In case of expansion valve trouble it is recommended that a new valve be installed. A clogged screen may be easily detected and the repair of it is very simple. Figure 303 illustrates one of the older type thermostatic expansion valve which was very popular. Removing an expansion valve which has a clogged screen necessitates removing both the liquid and gaseous refrigerant from the lines to be opened. The liquid line may be carefully heated, driving the liquid refrigerant back to the nearest shut-off valve, and this valve then closed. The coil is already evacuated (indicated by a warm coil); after determining that the low side pressure is at atmospheric pressure or higher, the suction line valve may be closed. The



A. Bellows
B. Bulb
C. Tubing
D. Rod
E. Bellows
F. Inlet
G. Adjustment

Fig. 303. An older style thermostatic expansion valve
(Courtesy of: Detroit Lubricator Company)

screen may now be removed after cleaning and drying the connections.

Upon assembling the coil after a repair has been made, the air should be removed by purging the coil through a loosened connection at the suction line shut-off valve. The purging may be performed by cracking the suction line valve and removing the air through the expansion valve low side fitting, if the low side pressure of the system is 10 pounds per square inch or more. In multiple systems all dry coils using expanion valves should be installed with individual shut-off valves for both the liquid and suction lines to each coil. A condition which results in trouble with thermostatic expansion valves is the attempt to adjust these valves in an effort to maintain too great a difference in temperatures in various boxes in the system. This gives rise to very erratic operation particularly in the coils which are closed off the most. The remedy for this difficulty is to use in addition to the thermostatic expansion valve one or more two-temperature valves in the suction line in appropriate places.

The problem of balancing the pressures in a multiple dry coil installation is very similar to those explained in connection with removing a low side float. Paragraph 411. An important factor, inasmuch as most of these systems are methyl chloride, is to dry thoroughly all connections before breaking them open. Frequently, the thermostatic expansion valve is attached to the coil in such a manner that this is difficult. It must be done by using a cloth saturated with carbon tetrachloride to prevent considerable future trouble due to moisture and dirt entering the system. In apartment house systems which use cooling coils surrounded with brine, the expansion valve is usually connected to the coil by means of a two-bolt flange. Lead gaskets should be used in an installation of this kind. Needless to say, as soon as the expansion

valve is removed, the refrigerant openings should be plugged with appropriate fittings. In multiple commercial installations in which finned coils are used, the expansion valve is usually attached to the coil by means of an S.A.E. flared connection. The flare nut in such an installation must be shellacked, or sealed from moisture, after the installation has been made and before the unit starts to operate; otherwise, ice will form between the nut and the tubing and in a short time will cause the tube to collapse or break. Figure 304.

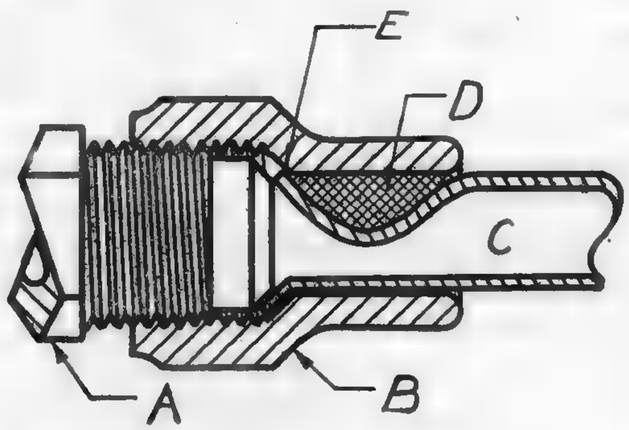


Fig. 304. An illustration of what happens when moisture freezes between the nut and tubing
A. Fitting; B. Flare nut; C. Tubing; D. Ice formation; E. Flare being pulled out of place

Other methods have been devised to prevent moisture from accumulating behind flare nuts. One method provides a rubber seal at the end of the flare nut and another method consists in drilling holes through the flare nut, the idea being that moisture will drain out and if ice does form it will release its pressure through the holes in the nut rather than against the tubing. As mentioned previously, the best sort of connection for use in the interior of the cabinets is a soldered flanged connection. Although soft solder is most popular for

this, many manufacturers are recommending silver soldering for all such joints as it is stronger and safer.

314. SERVICING TWO-TEMPERATURE VALVES:

As explained in Paragraph 302, two-temperature valves are automatic valves, which, when installed in the suction line, maintain a higher refrigerant pressure on one or more coils than that which exists in the rest of the system. The three types of two-temperature valves are:

1. The metering type
2. The snap action type
3. The thermostatic type

The metering type, two-temperature valve is the least expensive of the three and is used extensively in a beverage

Fig. 305. Showing two methods of preventing ice accumulation between a flare nut and the tubing
A. Drilled hole releases; B. Rubber seal
(Courtesy of: Imperial Brass Mfg. Company)
(Courtesy of: Harry Alter Company)

cooling and ice cream cabinet combination. It should be located in the suction line of the beverage cooler and maintains an evaporating pressure in the beverage cooler 10 pounds per square inch or 15 pounds per square inch above the pressure needed to maintain ice cream. The four troubles commonly encountered with this valve are:

1. Leaky needle
2. A stuck-shut valve
3. Out of adjustment
4. Frost accumulation on the bellows

If the valve is leaky, the beverage cooling coil will be too cold and there will be danger of freezing. This cold temperature may also be due to the two-temperature valve being adjusted too close and at too low a pressure. To determine which of the two troubles is prevalent, one may ask the proprietor if the valve has been adjusted recently. If the valve has not been tampered with, the trouble is very likely a leaky

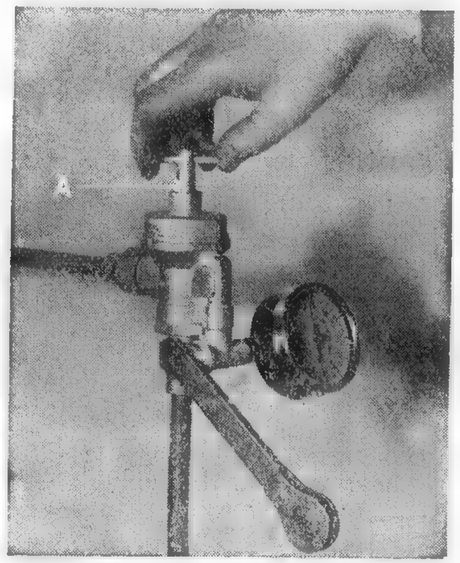


Fig. 306. An illustration of a metering type two-temperature valve with a compound gauge mounted on the valve for adjustment purposes
A. Adjusting screw
(Courtesy of: Fedders Mfg. Company)

needle. If the valve has been tampered with, one must readjust it by using a thermometer to obtain the correct beverage coil temperature. The adjusting nut should not be turned more than ½ turn at a time and a 15-minute interval should be allowed between each adjustment to permit the coil to completely respond to the new pressure.

For accuracy in making adjustments on two-temperature

valves, a low pressure gauge should be installed in the low pressure side of the cooling coil. Sometimes such a gauge opening is available, but in many cases it is not. Service work on such valves will be facilitated if the service man, when installing two-temperature valves, will install a shut-off valve

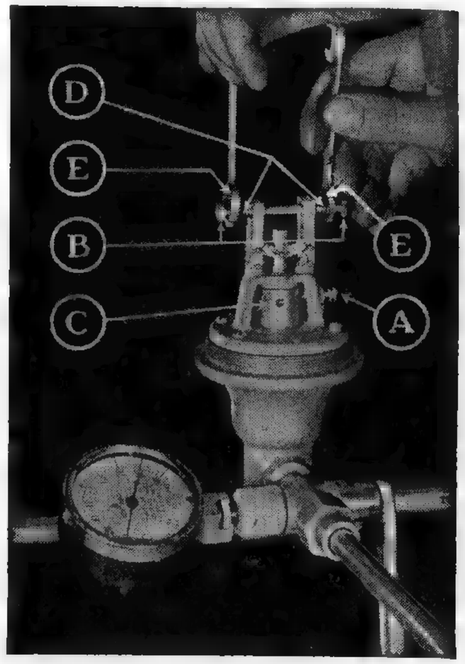


Fig. 307. An illustration of a snap-action type two-temperature valve with a compound gauge mounted on the valve for adjustment purposes
A. Lock pin; B. Lock nuts; C. Range adjustment; D. Differential adjustments; E. Wrenches
(Courtesy of: Fedders Mfg. Company)

with a gauge opening in the suction line to enable one to use a gauge to check this low side pressure. Figure 306.

A stuck-shut valve, which will be a very rare occurrence, may be easily checked by a non-freezing condition of the beverage cooler and an adequate refrigerant supply to the two-temperature valve, but not through it. This refrigerant

supply may be checked by cracking the flare nuts on the high pressure side of the two-temperature valve. Some of these two-temperature valves are provided with screens; a clogged screen will be indicated by a non-cooling condition of the beverage coil with symptoms similar to the stuck needle condition.

Frost accumulation on the bellows will occur only when the valve is located in or near a freezing compartment. The valve should be removed from the freezing compartment and the bellows covered with vaseline.

Exactly the same troubles are encountered with the snap-action, two-temperature valve as with the metering type. However, most of the snap-action valves are provided with a gauge connection in the nature of a one-way service valve mounted on the two-temperature valve body. This gauge connection makes the adjustment of the valve very simple and is a means whereby one may determine whether the valve is leaking or out of adjustment. Figure 307. Occasionally, trouble is encountered because of presence of moisture and its freezing on the exterior of the valve bellows. This moisture prevents the bellows from working evenly and will tend to give erratic operation to the unit. Any frost accumulation on the bellows should be removed and the bellows coated with vaseline to prevent any further such accumulation.

The thermostatic two-temperature valves offer the same troubles, causes, and remedies as the above two and in addition it has troubles resulting from the thermostatic element. These troubles are exactly the same as mentioned in regard to the thermostatic expansion valves. They are:

1. loss of the charge from the thermostatic element
2. frost on the bellows
3. poor power element contact with the coil
4. pinched capillary tube

5. wrong adjustment

These troubles are checked in the manner similar to the method of checking the thermostatic element in thermostatic expansion valves.

415. PERIODIC INSPECTIONS:

The capital investment in any commercial refrigeration installation represents hundreds of dollars. The inherent construction of most mechanisms is such that any troubles in the system will be accumulative, that is, one trouble will cause others. It is, therefore, essential that all commercial machines should be completely checked over periodically. The service man should devise a systematic method of doing this in order that no detail may be overlooked. Inspections should cover such things as the electrical connections and motor, compressor noises, amount of refrigerant, the water flow, gas leaks, coil conditions, the supports for the tubing, the coils, and the condensing unit operation.

416. REFRIGERATION SERVICE CONTRACTING:

Much has been done during the past few years in respect to contracting for refrigeration service. Many large companies have developed definite policies in this respect, and many of the larger independents are featuring this type of servicing. The usual contracting plan provides for a charge at a definite monthly or weekly rate, for which the service company agrees to keep the refrigerating mechanism in good condition. This charge may or may not cover parts depending upon how the contract is written. The success of such a plan depends upon a large volume of contracts in order to break even on any extremely bad installations. It is possible that some multiple installation may be completely ruined in a very short time

from some very minor trouble; a service contract on such an installation certainly would be unprofitable to the service company, and only a large number of profitable contracts would enable an organization to tide over a situation of this kind. Contracts may be on a time and material basis. Two features of a service contract which appeal to the purchaser are the 24-hour available service clause and an absolute guarantee of any work done.

417. SERVICE ESTIMATES:

Many organizations operating refrigerating equipment ask for bids when a repair, replacement, or service is required. A service organization bidding on such work should have a man who specializes in estimating work of this kind. This man should be thoroughly acquainted with material costs, service problems, and labor costs; he must be able to judge the time necessary to do the repair. A pleasing personality in combination with a rapid and accurate estimating ability is essential.

418. REVIEW QUESTIONS:

Answers to the following questions may be found on page 830.

1. Why do code installations require the installation of the tubing within a conduit?
2. Why must hand valves be provided in the refrigerant lines to each individual coil?
3. Why is it necessary to run refrigeration tubing parallel with beams rather than across them?
4. Why is it necessary to mount low side float coils absolutely level?
5. Where are two-temperature valves usually located?
6. What is "Greenfield" tubing?

7. Explain the method whereby a multiple dry coil system is cleaned of air after assembly.
8. Why is it not always necessary to dehydrate a new system after installation?
9. What would be the purpose of a dehydrator placed in a new methyl chloride installation?
10. Why are hard drawn copper tubing and streamline fittings becoming popular?
11. How is a lack of refrigerant in a low side float refrigerant control in a multiple installation indicated?
12. What may be wrong if a thermal expansion valve coil suddenly starts to frost excessively at the expansion valve, but the coil near the suction line connection is dry?
13. How are flare nuts protected so moisture cannot get under them and freeze?
14. Why is it not always necessary to remove the refrigerant from a low side coil in case of a clogged screen?
15. What must be done to balance the low side pressures in a multiple coil installation in case the system is running on a 5-inch vacuum?
16. Are commercial systems normally charged through the high pressure side or low pressure side?
17. What safety precautions should a service man follow when charging a system through the high side?
18. Why are soldered flanged fittings recommended for use in making inside cabinet connections?
19. What is the purpose of the felt and fine mesh screen in a dehydrator?
20. Why must a system be very carefully checked for leaks if a lack of refrigerant is discovered in the system?
21. What is the difference between a dehydrator and a neutralizer?
22. What special precautions must be followed when installing a suction line?

23. Why must calcium chloride be kept in a sealed container?
24. What cleaning fluid should be used to clean joints before being opened?
25. What may cause a water-cooled condensing unit to short cycle?

CHAPTER XVI

REFRIGERANTS

To obtain a transfer of heat from the inside of a box to the outside or in order to refrigerate, a heat carrier must be used.

Fluids which can be changed easily from a liquid to a gas and from a gas to a liquid are used as the medium because such a change of state is always accompanied by a change in heat content. Some fluids are better than others and the most popular, especially for automatic refrigeration, are discussed in the next few paragraphs.

419. REQUIREMENTS FOR REFRIGERANTS:

There are certain desirable characteristics which a fluid used as a refrigerant should possess. They are:

1. It should be non-poisonous.
2. It should be non-explosive.
3. It should be non-corrosive.
4. It must be non-inflammable.
5. Leaks should be easy to detect.
6. Leaks should be easy to locate.
7. It should operate under low pressures (low boiling-point).
8. It should be a stable gas.
9. It should be easy to lubricate parts moving in its presence.
10. It should be non-toxic.
11. It should have a well balanced latent heat of evaporation value per unit of weight.
12. It must have a small relative displacement to obtain a certain refrigeration effect.

13. The difference between the vaporizing pressure and the condensing pressure should be a minimum.

Common refrigerants in use at present are:

1. Sulphur dioxide SO_2 ..... (Par. 421)
2. Methyl chloride CH_3CL ..... (Par. 422)
3. Ammonia NH_3 ..... (Par. 423)
4. Dichlorodifluoromethane (Freon) (F-12) $C\ CL_2F_2$ ..... (Par. 424)
5. Iso-butane (Freezol) ..... (Par. 425)
6. Ethyl chloride C_2H_5CL ..... (Par. 426)
7. Carbon dioxide CO_2 ..... (Par. 427)
8. Methyl formate $C_2H_4O_2$ ..... (Par. 428)
9. Methylene chloride (Carrene) CH_2CL_2 ... (Par. 429)
10. Dichlorotetrafluoroethane (F-114) $C_2CL_2F_6$ ..... (Par. 430)
11. Dichloromonofluoromethane F-21 (Thermon) $CH\ Cl_2F$ ..... (Par. 431)

The first requirements are almost self-explanatory because it is only natural that an automatic mechanism be safe from the possibility of being poisonous, inflammable, or even explosive. The refrigerant must be non-corrosive in order that the more common metals may be used for constructing the machine and for giving a long life to all the parts. The refrigerant must be such that its presence and its source may be very easily detected in case of leaks. This is mainly a service feature. It is desirable to keep normal pressures in the refrigerator as close to atmospheric pressure as possible, because any excessive differences greatly aid any leaking tendencies, overwork the compressor, and decrease the efficiency of the valves. In order to stand years of repeatedly changing its state, it is necessary to use a very stable gas or refrigerant in an automatic machine and the refrigerant

Fig. 308. A table of common properties of popular refrigerants

Name	Chemical Symbol	Trade Name	Molecular Weight	Color of Liquid	Odor	Toxity	Inflammability	Pressure in #/□″ abs at 32° F.	Pressure in #/□″ abs at 86° F.	Latent Heat at 5° F.	Sp. Heat of Liquid at 5° F.	Critical Temperature of	Critical Pressure #/□″ abs.	Sp. Volume of Gas at 5° F.	Density of Liquid in a 5° F.#/ cu. ft.	CP/CV	Sp. Heat of Liquid at 86° F.
Sulphur Dioxide	SO_2	.....	64.06	Non	Pungent	High	Non	11.81	66.45	172.3	.34	314.8	1141.5	6.421	92	1.256*	.34
Methyl Chloride	CH_3Cl	.....	50.489	Non	Sweet	Med.	Slight	20.89	95.53	180.6	.45	289.6	969.2	4.530	61	1.20	.4
Ammonia	NH_3	.....	17.031	Non	Pungent	High	Slight	34.27	169.2	565	1.10	271.4	1651	8.150	41.11	1.247	1.10
Iso-Butane	$(CH_3)\ CH$	Freezol	58.07	Non	Sweet	.....	Yes	14.0	65.76	173.5	.5	272.7	522	6.46	37.40	1.11	.75
Ethyl Chloride	C_2H_5Cl	Aleozol	64.51	Non	Etheral	Med.	Yes	4.65	27.10	177	.47	369	764	17.55	59.00	1.13	.42
Freon	CCl_2F_2	F-12	120.9	.....	Sweet	Low	Non	26.61	107.9	69.46	.215	232.6	582.0	1.485	90	.....	.243
Carbon Dioxide	CO_2	.....	44.005	Non	Non	Med.	Non	334.4	1039.0	116	.5	87.8	1066.2	.2673	61.22	1.30†	1.95
Methyl Formate	$C_2H_4O_2$	.....	.....	.....	Slight	.....	Slight	1.96	13.69	236	.515	417	870	46.7	. ....	.....	.515
Methylene Chloride	CH_2Cl_2	Carrene	84.9	.....	Sweet	.....	.....	1.17	10.6	162.1	.34	421	670	50.58	.....	.....	.34
F-114	$C_2Cl_2F_4$	.....	.....	Non	Sweet	.....	Non	6.76	36.2	55‡	.15‡	.....	.....	.....	99.1‡	.....	.20‡
F-21	.....	Thermon	102.92	.....	Sweet	Low	.....	5.5	30.5	105.5	.26	.....	.....	8.83	90.01	.....	.26

*at 70° F. †at 32° F. ‡at 70° F

must not be harmful to the lubricants used. Figure 308 is a table of properties of popular refrigerants.

420. THE SELECTION OF A REFRIGERANT:

To have an economical refrigerator mechanism the designer must choose the refrigerant that will qualify and also be good in the following respects: In order to refrigerate, the gas when passing from a liquid to a gas must absorb heat; that gas which absorbs the most heat per pound as it changes its state is usually the most desirable. That is, any fluid which will answer the practical requirements and which requires a great deal of heat to change it from a liquid to a gas is the refrigerant wanted. There are several other design requirements to be met, one of which is that the specific volume of the gas, and volume per unit of weight, must be kept small in order that a compressor of small size may be used.

It must not be forgotten that cost and availability determine to a considerable extent the kind of fluid used.

All of the above factors decide which refrigerant is to be used; the final choice is that one which satisfies the greatest number of all of the above and all of the necessary requirements. The following is a brief summary of the principal characteristics of the more common refrigerants:

421. SULPHUR DIOXIDE (SO_2):

Sulphur dioxide is commonly used in the automatic and refrigeration units. Sulphur dioxide was first produced in 1775 and in addition to its use as a refrigerant, it has considerable use in the industries for such purposes as refining sugar, bleaching wool, preserving food, and fumigating. It is usually produced by the burning of sulphur in the presence of oxygen. Its chemical formula is SO_2. At atmospheric pressure and all temperatures above 14°F. it is a colorless

gas of very pronounced odor. Its boiling-point at atmospheric pressure is 14°F. and melting-point —103.4°F. Its critical temperature is about 314.8°F. As a result of its boiling temperature being at 14°F., it is necessary to operate at pressures somewhat below atmospheric when temperatures below this figure are required. Little difficulty, however, has been experienced as a result of this and other advantages tend to offset it. The boiling-point, for instance, makes condensation of the gas easy and it is rarely necessary to exceed 100 pounds per square inch in the condenser. Water-cooled machines with as low as 30 pounds pressure in the high side are not uncommon in winter operation. The latent heat of sulphur dioxide at 5°F. is 169.38 B.T.U. per pound. This is not quite one-third of the value for ammonia under the same conditions; and although it makes necessary a circulation of almost three times the amount of sulphur dioxide as of ammonia for the same amount of refrigeration, it is not a disadvantage in the case of the small capacity machine, for it permits the construction of the parts of a sufficiently large size to be practical and efficient.

The chemical bond between the elements of the sulphur dioxide is particularly strong so that deterioration of the refrigerant does not take place as a result of the continued repetition of evaporation and condensation. It is therefore unnecessary to renew the refrigerant within the system except in the case of actual loss.

Sulphur dioxide is non-explosive and non-inflammable; although of an irritating odor, it is comparatively non-toxic. As little as three parts by volume, in one million parts of air, is enough to produce a noticeable odor and thus call attention to the presence of the gas. In addition to its odor, SO_2 leaks are easily detected and located by means of a 28 per cent solution of ammonia. With this method the most minute leak can be detected.

The lubricating problem in connection with SO_2 is perhaps easier than with any other refrigerant, for sulphur dioxide itself possesses certain lubricating properties. It does not react chemically with the proper kind of oil and is practically 50 per cent heavier than the oil. This latter permits the separation of the lubricant from the refrigerant, which is essential to the proper kind of operation. Most oils are somewhat soluble in SO_2 8 to 10 per cent, but the usual extent of solubility is more of an aid than otherwise, for it permits of a desirable circulation of the lubricant with the refrigerant. The best oil is thoroughly dehydrated, pure mineral oil.

The only characteristic of sulphur dioxide that is not desirable from the standpoint of its use as a refrigerant is its action in the presence of water. SO_2 combines with water to form sulphurous acid, which attacks the ferrous metals of the system. There is no danger of this, however, when water is not present, and modern methods of manufacture have entirely overcome the corrosion hazard. "Baking" or heating all the parts before assembling them into the system minimizes corrosion. Carbon tetrachloride is the best cleaning agent for cleaning refrigerator parts, and it may be safely used regardless of what refrigerant is used. Refer to Figure 309 for the vapor pressure curves for this refrigerant.

422. METHYL CHLORIDE (CH_3Cl):

Methyl chloride is classed as a non-corrosive and non-poisonous refrigerant, although the breathing of sufficiently large quantities of it will result in the suspension of the respiratory functions. In smaller concentrations it has the effect of a mild anesthetic and in odor is similar to chloroform. Its boiling-point at atmospheric pressure is —11.36°F. and melting-point —132.7°F. Its critical temperature is

289.6°F. The latent heat of evaporation at 5°F. is 178.5 B.T.U. per pound. Condenser pressures are in the vicinity of 100 pounds per square inch for the methyl chloride machine although, with the use of water-cooling in the condenser, these may be considerably reduced. Methyl chloride is very slightly combustible and explosive within narrow

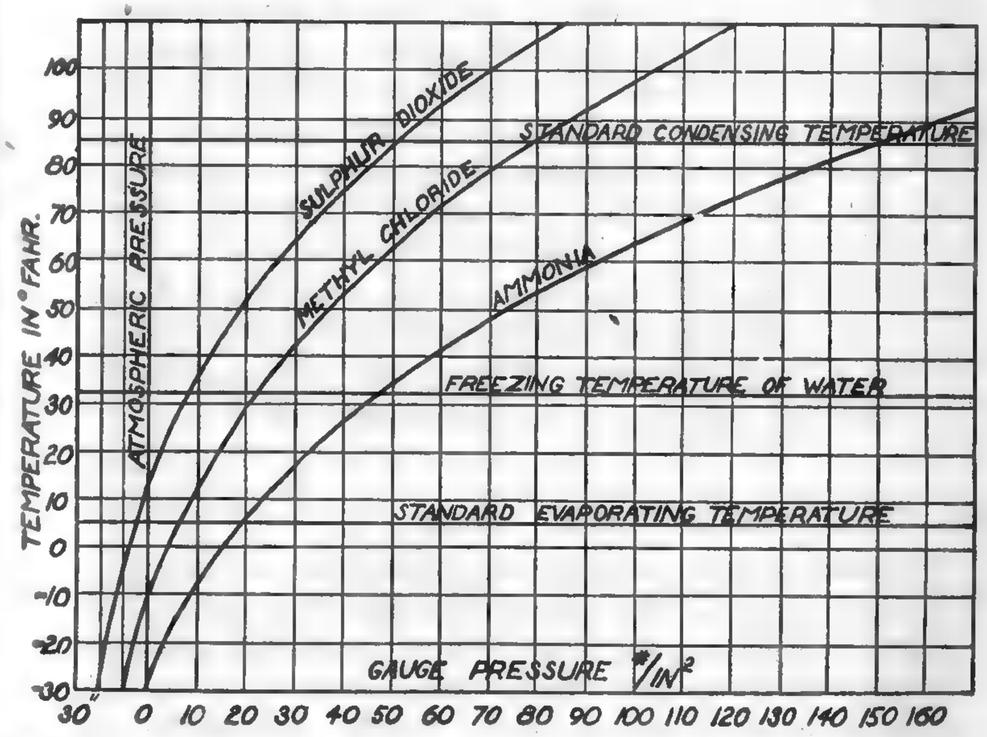


Fig. 309. Vapor pressure curves for ammonia, methyl chloride, and sulphur dioxide

limits although not to such an extent as to make its use dangerous.

Methyl chloride was first used as a refrigerant to some extent by the French Navy and the British Expeditionary Forces in the Soudan, which were equipped with ice machines that used it. A number of automatic machines now on the market are using methyl chloride with very good results.

The two greatest difficulties presented by the use of methyl chloride are its effect on the lubricating oil in the machine and the difficulty with which leaks in the system may be detected. This refrigerant dissolves many of the common lubricants and its use increases the lubricating problem. Mineral oil should be used with methyl chloride, although glycerine was used in one of the first Copeland refrigerators. The best methods for detecting leaks in a methyl chloride system are the use of a soap solution or a flame test. A curious reaction in a methyl chloride mechanism is the coating of the compressor parts with copper. The best explanation is that the presence of moisture in the system forms an acid (HCL) which causes this. The flame test means that if methyl chloride is passed through a colorless flame in the presence of hot copper, the flame will turn a brilliant blue-green. See Paragraph 191. Refer to Figure 309 for the vapor pressure curves for this refrigerant.

423. AMMONIA (NH_3):

Ammonia is one of the most common of all the refrigerants. It is a chemical compound of nitrogen and hydrogen (NH_3) and under ordinary conditions is a colorless gas. Its boiling temperature at atmospheric pressure is —28°F. and its melting-point from the solid —108°F. The low boiling-point makes it possible to secure refrigeration at temperatures considerably below zero without resorting to pressures below atmospheric in the evaporator. Its latent heat at 5°F. is 565 B.T.U. per pound, so that large refrigerating effects are possible with the use of relatively small-sized machinery. Condensers for ammonia machines are almost always of the water-cooled type. Under ordinary operating conditions, the condenser pressure will vary from 150 to 200 pounds per square inch.

Ammonia is somewhat inflammable and with the proper mixture of air will form an explosive mixture. Accidents from this source, however, are rare. Ammonia gas is not classed as poisonous, but its effect on the respiratory system is so violent that only very small quantities of it can be breathed. About .35 volumes per 100 volumes of air is the strongest concentration bearable for any length of time. Because of its pronounced and distinguishable odor and also the white smoke that it forms in the presence of sulphur vapor, ammonia leaks may be quickly and easily detected.

Ammonia, although attacking copper and bronze in the presence of a little moisture, does not corrode iron or steel, and it presents no special problems in connection with lubrication other than those attendant upon the extreme temperatures encountered in the system. Ammonia gas is extremely soluble in water. It is used in large machines and in practically all of the absorption types. Refer to Figure 309 for the vapor pressure curves for this refrigerant.

424. FREON (F-12):

Freon or dichlorodifluoromethane is a colorless, almost odorless gas with a boiling-point of —21.7°F. at atmospheric pressure. It is a non-toxic, non-corrosive, non-irritating, and non-inflammable. It is generally prepared by replacing chlorine in carbon tetrachloride with fluorine. Chemically it is inert at ordinary temperatures and thermally stable up to 1022°F.

Freon has a relatively low latent heat value and this is a decided advantage in the smaller refrigerating machines, because the large quantity of liquid circulated will permit the use of less sensitive, more accurate, and more positive operating and regulating mechanisms.

It operates at a low but positive head and back pressure, and with a good volumetric efficiency.

A Freon leak may be detected by means of a halide lamp. This lamp may be described as a torch burning alcohol, which under normal conditions produces a colorless flame. A tube fastened to the base of the burner is used to conduct the air suspected of containing the vapor through the flame and over metallic copper. Owing to the breaking down of the refrigerant in the flame a volatile copper halide is formed, and the flame color changes from the normal colorless to bright green if the air contains as much as 0.01 per cent of the gas.

It is only slightly soluble in water, and the solution formed is very slightly corrosive to any of the common metals used in refrigerator construction. The addition of mineral oil to the gas has no effect upon the corrosive action, except possibly to decrease the amount of discoloration caused by the free water.

This refrigerant permits installations to be made in locations where other refrigerants cannot be used because of the hazard of fire.

1. It is non-inflammable.
2. It is non-explosive.
3. It is non-irritating.
4. It is non-toxic.
5. It has no odor even in fairly high concentrations.
6. It is stable.
7. It is non-corrosive.
8. It has no effect on flowers, fruits, vegetables, dairy products, furs, or other materials being refrigerated.

From an engineering viewpoint, complicated heat tables are used to study the properties of the refrigerants, but all that is needed to be known in order to understand the operation and to be able to service the mechanism is the temperature-pressure curve of the fluid, i.e., the vaporization temperature at any pressure. Figure 310.

425. ISO-BUTANE $(CH_3)_3CH$) (FREEZOL):

Iso-Butane, or Freezol, is a refrigerant of the butane family of compounds which was used by the Copeland Company in

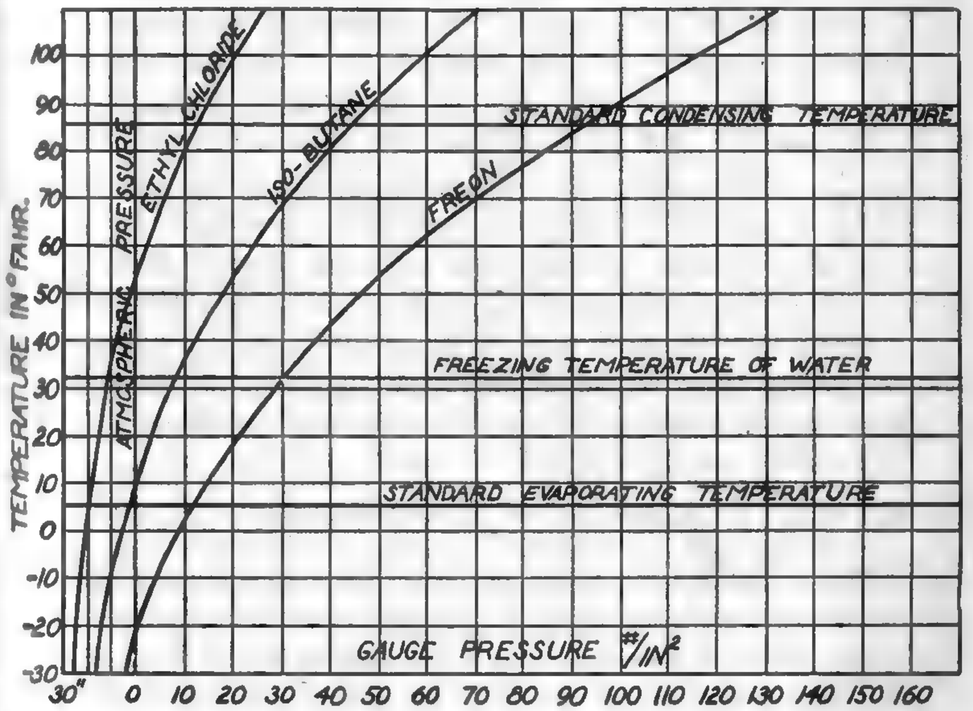


Fig. 310. Vapor pressure curves for Freon, iso-butane, and ethyl chloride

their refrigerators until 1933. Its properties are such that it boils at 10.3° F. at atmospheric pressure and has a freezing-point of —229° F. A good feature of the gas is its critical temperature of 273° F. which is above the temperature of any refrigerator apparatus. The refrigerant is non-corrosive in the presence of water and the lubrication of the system is not difficult. Its chemical formula is the same as that of

butane C_4H_{10} but the bonds are different, giving completely different physical characteristics. The gas has a specific volume of 7.17 cubic feet per pound at 0°F. and a latent heat of 159.5 B.T.U. per pound at 5°F. The only method of testing the system for leaks is to build up a positive pressure and use oil or soap bubbles. A seal leak may be detected by submerging the compressor in a quantity of water after a pressure is built up in the crankcase with air or other means. Another method is to run the compressor with both the suction and discharge service valves closed and with gauges in the gauge openings. An increase in the high side gauge reading indicates a low side leak. A trace of sulphur dioxide may be put into the system for testing for leaks, but the idea is not recommended because if the system is not moisture free, corrosion will follow. Moisture in the normal system will freeze at the expansion valve and clog the orifice, but a dehydrator will remove this trouble. Refer to Figure 310 for the vapor pressure curves for this refrigerant.

426. ETHYL CHLORIDE (C_2H_5Cl):

Ethyl chloride is a little used refrigerant which is similar in many respects to methyl chloride, being a member of the same chemical family. The outstanding difference is found in the low pressure at which it evaporates. At atmospheric pressure, the boiling temperature of ethyl chloride is 55.6°F. Therefore, it is necessary to operate with an evaporator pressure below that of the atmosphere. This disadvantage is somewhat counterbalanced by the correspondingly low pressure encountered in the condenser. Pressures in the condenser of from 10 to 20 pounds per square inch are common, and, as a result of the low pressure operations, ethyl chloride is more suited for use in the rotary compressor than in the more common reciprocating type.

The use of ethyl chloride presents the same difficulty of lubrication and leak detection as does methyl chloride, and the substance itself possesses similar explosive and combustible characteristics. Its odor is similar to that of ether and its effect is of a like nature but much milder. Its latent heat of evaporation at 5°F. is 177 B.T.U. per pound. It is not being used in any refrigerator produced at present, although it was used in the Holmes two-stage rotary machine and in the Welsbach. Refer to Figure 310 for the vapor pressure curves for this refrigerant.

427. CARBON DIOXIDE (CO_2):

Carbon dioxide differs considerably in its characteristics from any of the refrigerants already discussed. This difference is especially marked in the matter of the pressures encountered within the machine, the operating pressures in the CO_2 machine being many times higher than those encountered in the others. At ordinary temperatures and pressures, CO_2 is a colorless and odorless gas considerably heavier than air. It is non-explosive, non-inflammable, and non-toxic. The boiling-point of carbon dioxide is so extremely low that even at 5°F. a pressure of over 300 pounds per square inch is required to prevent its evaporation, while with a temperature of 80°F. in the condenser, a pressure of almost 1,000 pounds per square inch is required to liquefy it. Its critical temperature is 87.8°F. so that it can be used only where relatively cold water is available for condenser cooling, and cannot be used at all with the air-cooled type of condenser. It is not used in local domestic machines, but has been used in Europe.

As a result of the high operating pressures, the compressor of the CO_2 machine is quite small for relatively large refrigerating capacity, and the machine is therefore particularly adapted to use on shipboard where space is at a premium.

The latent heat of evaporation of carbon dioxide at 5°F. is 116 B.T.U. per pound. Leaks may be located by an oil film or soap solution. A large leak will be easily detected from the cloud of condensation or vapor produced at the leak. This refrigerant is used in large installations where leaks will soon be detected by the operator in charge of the system.

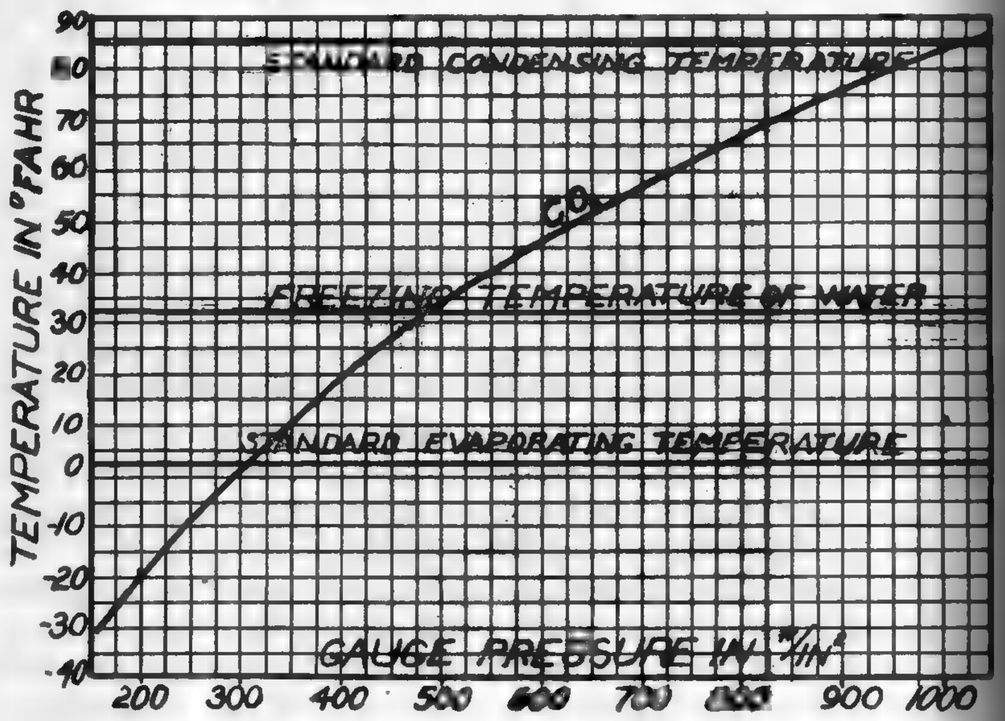


Fig. 311. Vapor pressure curve for carbon dioxide

Refer to Figure 311 for the vapor pressure curve for this refrigerant.

428. METHYL FORMATE ($C_2H_4O_2$):

The General Electric Corporation has produced some refrigerators using methyl formate. This is a relatively new refrigerant. The chemical formula is HCO_2CH_3 or $C_2H_4O_2$

and its operating pressure at 5°F. is 25.9 inches vacuum while at 86°F. its pressure is 2 inches of vacuum. The gas is slightly flammable and at 5°F. 1 pound forms 47 cubic feet of gas. Its freezing-point is —148°F. and it has a critical temperature of 418°F. The latent heat of the gas at 5°F. is approximately 236 B.T.U. per pound. The specific gravity of the liquid is .9531 and the specific heat of the liquid is .515 B.T.U. per pound. The General Electric unit, which uses this refrigerant, has a vertically mounted motor under a dome driving direct rotary compressor. The unit looks similar to this Company's sulphur dioxide monitor top refrigerator. The refrigerant behaves like methyl chloride in the presence of moisture. Refer to Figure 312 for the vapor pressure curves for this refrigerant.

429. METHYLENE CHLORIDE (CH_2Cl_2) (CARRENE):

This refrigerant, more popularly known as Carrene, is a very low pressure refrigerant having operating pressures of 27.5 inches vacuum at 5°F. and an 8.8-inch vacuum at 86°F. Its chemical formula is CH_2Cl_2 and its freezing temperature is —142°F. The gas has a slight odor which is not distasteful. It may be carried or stored in tins, although the refrigerant evaporates under room conditions fast enough to warrant sealing the cans in which it is stored. The refrigerant may be poured into a system through a funnel when charging. The specific heat of the liquid is .34 and its boiling-point at atmospheric pressure is 105°F. Its critical temperature is 421°F. and it has a latent heat of 162.1 B.T.U. per pound at 5°F. Carrene is used by the Carrier Corporation in air-conditioning equipment and in the Grunow domestic refrigerator. In combination with water the corrosive active is negligible, but any moisture may freeze at the refrigerant control. The Grunow uses a 5/8-inch O.D. suction line be-

cause this refrigerant forms 49.9 cubic feet of gas per pound at 5°F. However, this does not increase the power required to run the machine as the high side pressure is below atmosphere pressure. Refer to Figure 312 for the vapor pressure curves for this refrigerant.

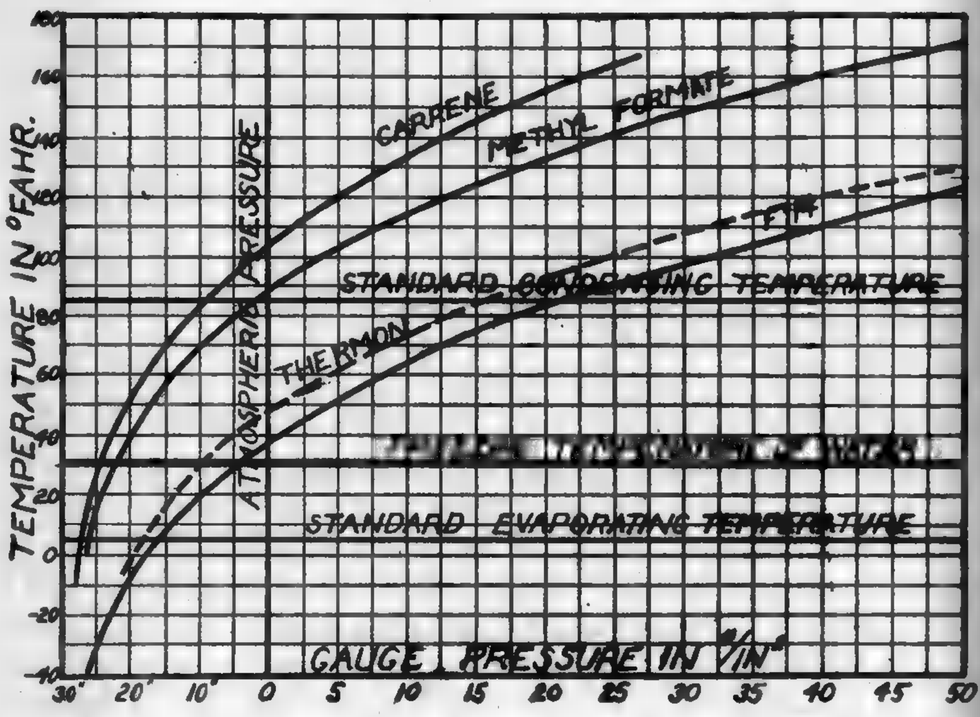


Fig. 312. Vapor pressure curve for methyl formate, Carrene, F-114, and Thermon (F-21)

430. DICHLOROTETRAFLUOROMETHANE ($C_2Cl_2F_6$) (F-114):

The 1934-39 Frigidaire Standard refrigerator mechanism uses a refrigerant popularly called F-114. This machine is a hermetic rotary machine using a capillary refrigerant control. The refrigerant has a boiling-point at atmosphere pressure of 38°F. The refrigerant has very similar properties to that of F-12 in regard to water and oil combination. The

refrigerant is of the same family as F-12, but its operating pressures are considerably lower. At 86°F. it has a pressure of 21.5 pounds per square inch gauge while at 5°F. its pressure is 16.1 inches of mercury vacuum. It is a colorless liquid having a slight odor. In addition to being non-explosive it is a non-corrosive liquid which will not corrode even in the presence of water. The halide torch is used to test it for leaks. Its boiling-point at atmospheric pressure is 38.4°F., while at 20°F. it has a latent heat of vaporization of 55 B.T.U. per pound. The specific volume of this liquid and the specific heat of the vapor at 70°F. are .0109 cubic feet per pound and .15 B.T.U. per pound respectively. The volume of the vapor when saturated at 70°F. is 1.15 cubic feet per pound, and the specific gravity of the liquid at this temperature is 1.47. The Frigidaire Corporation, who are continuing this system in 1935, advertise that their unit which uses this refrigerant consumes less electricity than a 60 watt bulb. This system was one of the first to utilize the principle of allowing the high and low side pressures to equalize when the unit stops. Allowing the pressures to equalize when the unit stops effectively unloads the compressor for starting. Refer to Figure 312 for the vapor pressure curves for this refrigerant.

431. DICHLOROMONOFLUOROMETHANE (CH Cl_2F) (THERMON) (F-21):

The 1935 Crosley rotary units are using a new refrigerant called Thermon. It is a refrigerant very similar to F-114, having many of its characteristics, and its operating pressures are almost the same. Its boiling temperature under atmospheric pressure is 48°F. It is practically non-explosive and non-inflammable. Its odor is similar to chloroform and it is not irritating in any way. It mixes in practically all proportions with oil and may be tested for leaks by using a

halide torch. It is a non-corrosive and non-poisonous refrigerant. It operates at 18.8 inches of vacuum at 5°F. and at 15.8 pounds per square inch at 86°F. Its liquid has a density at 5°F. of .0111 cubic feet per pound and at 86°F. of 0.119 cubic feet per pound. Its saturated vapor has a density at 5°F. of 8.83 cubic feet per pound and at 86°F. of 1.87 cubic feet per pound. The specific heat of the liquid is approximately .26 B.T.U. per pound per °F. The latent heat of the refrigerant at 5°F. is 105.5 B.T.U. per pound. Refer to Figure 312 for the vapor pressure curve of the refrigerant.

432. USE OF THE PRESSURE TEMPERATURE CURVES:

Figures 309, 310, 311, and 312 represent the various pressures produced by the refrigerants under various temperatures. The vertical scale is the °F. temperature scale. To determine the pressure of the refrigerant at any particular temperature, read horizontally from the temperature reading until the curve of the particular refrigerant is reached; then move directly down and the pressure may be read on the horizontal scale. For example, the pressure of sulphur dioxide at a refrigerant temperature of 75°F. is 40 pounds per square inch gauge. The temperature is always the temperature of the refrigerant. The same curve may be used for determining both the condensing and evaporating temperatures and pressures. The condensing values are the higher values. When using this chart, several things must be kept in mind:

1. The temperature of the refrigerant in the cooling coil is approximately 8°F. to 12°F. colder than the coil when the compressor is running.
2. The temperature of the refrigerant in the cooling coil is the same as the coil temperature when the compressor is stopped.

3. The temperature of the refrigerant in an air-cooled condenser is approximately 30°F. to 35°F. warmer than the room temperature.
4. The temperature of the refrigerant in a water-cooled condenser is approximately 25°F. warmer than the average water temperature.
5. The temperature of the refrigerant in the condenser is the same as the temperature of the cooling medium after the unit has been shut off for 15 to 30 minutes.

433. CHANGING REFRIGERANTS:

It is not recommended to change refrigerants in a machine that has been designed for a particular refrigerant. However, if this has to be done in extreme cases, the following pointers may prevent considerable trouble. In general, it is best to use expansion valves and a dry system when substituting refrigerants rather than attempt to recalibrate float controls; also it should be remembered that many small engineering features that are incorporated in a unit to promote efficiency for the particular refrigerant selected will be lost if a change in refrigerant is made.

434. SUBSTITUTING METHYL CHLORIDE FOR SULPHUR DIOXIDE:

It is possible to make this change, but a smaller pulley should be put on the motor, for the compressor will not have to run as fast for methyl chloride; also the higher head pressure under which methyl chloride operates makes it necessary to use a smaller pulley on the motor or to replace the motor with a larger one. If any kind of float refrigerant control is used, it must be replaced with the float for methyl chloride; the density of the two refrigerants is entirely different, as may be seen from the table (Figure 308). It is common

practice to use an expansion valve to replace float refrigerant controls when changing refrigerants.

435. SUBSTITUTING SULPHUR DIOXIDE FOR METHYL CHLORIDE:

This may be done, but the compressor must be speeded up and the system must be thoroughly dried out (baked at 200°F. under a vacuum for 8 to 24 hours). The speeding up of the compressor is necessary to handle the increased gas volume. Because of the lower high side pressure, this can usually be done by increasing the size of the motor pulley and without changing the motor. Again, attention must be given to the refrigerant control, if it is other than an expansion valve, to make sure that all floats are calibrated for the refrigerant being used.

436. SUBSTITUTING SULPHUR DIOXIDE FOR ISOBUTANE:

It will usually be safe to make such a change without making any change in the pulley sizes, although the motor will have to work a little harder unless a smaller pulley is put on it. Again, this system must be thoroughly dehydrated by being baked at 200°F. under a vacuum for 8 to 24 hours. Also, the refrigerant controls must be checked to make sure that they are calibrated for the new refrigerant.

437. SUBSTITUTING SULPHUR DIOXIDE FOR ETHYL CHLORIDE:

It is not recommended that this change ever be made, as many radical changes are necessary. However, if it is done, a larger motor must be installed and the system thoroughly dehydrated as for other sulphur dioxide installations. Also, the refrigerant controls must be changed.

438. REVIEW QUESTIONS:

Answers to the following questions may be found on page 833.

1. Why is ammonia not popular in the compression type, domestic machines?
2. How may one test for sulphur dioxide leaks?
3. Why has ethyl chloride been discontinued as a domestic refrigerant?
4. What is a common head pressure for air-cooled sulphur dioxide refrigerators?
5. What is the method used to locate methyl chloride leaks?
6. What are the low side pressures at 5°F. for sulphur dioxide and methyl chloride?
7. What does "halide" mean?
8. What fuel is used in a halide lamp?
9. What refrigerator uses Carrene?
10. What properties must oil used with sulphur dioxide have?
11. What properties must oil used with methyl chloride have?
12. What other name is F-12 known by?
13. What is the pressure of sulphur dioxide at 95°F.?
14. What is the temperature of methyl chloride under a pressure of 12 pounds per square inch gauge?
15. What is the pressure of carbon dioxide at 0°F.?
16. Is it advisable to substitute refrigerants in a system?
17. How may one arrive at the refrigerant temperature in an air-cooled condenser?
18. What refrigerator uses Thermon as a refrigerant?
19. Name the refrigerants that may be tested for leaks with the halide torch?
20. What will be the high side pressure (gauge) in an air-cooled condenser using methyl formate while the condensing unit is running if the room temperature is 75°F.?

CHAPTER XVII

TECHNICAL CHARACTERISTICS

439. TUBING TABLES (COPPER):

The tubing must be dehydrated, annealed, and either tin-coated or copper finished.

The sizes are always referred to by outside diameter and the tubing may be obtained in 50 and 100 foot lengths, although some companies furnish 20 and 25 foot lengths.

The tubing is sold either by the pound or by the foot. The three most popular sizes are the 1/4 inch, 3/8 inch and the 1/2 inch O.D., while the 5/16 inch and 7/16 inch O.D. sizes are considered obsolete. The tinned tubing is to be used in moist locations and in cabinets.

COPPER TUBE SPECIFICATIONS

Size Outside Diameter	Wall Thickness	Approximate No. of ft./lb.	Wt./Lineal ft. in lbs.
3/16	.035	16 1/2	.065
1/4	.035	11	.092
5/16	.035	8 1/2	.119
3/8	.035	7	.145
7/16	.035	6	.171
1/2	.035	5	.198
5/8	035	4	.251
3/4	035	3 1/4	304

440. HARD DRAWN COPPER TUBING:

Size	Outside Diameter	Inside Diameter	Wall Thickness	#/ft.
1/8	1/4	.200	.025	.068
1/4	3/8	.315	.030	.126
3/8	1/2	.430	.035	.198
1/2	5/8	.545	.040	.284
3/4	7/8	.606	.045	.454
1	1 1/8	1.025	.050	.653
1 1/4	1 3/8	1.265	.055	.882
1 1/2	1 5/8	1.505	.060	1.14
2	2 1/8	1.985	.070	1.75
2 1/2	2 5/8	2.465	080	2.48
3	3 1/8	2 945	.090	3.33

441. HEAT CONDUCTIVITY:

CONDUCTIVITY

Miscellaneous Substances

Material	K
Air	.175
Concrete wall	8.00
Glass	5.0
Lead	243.0
Vacuum, high	004

(Courtesy of: American Society of Refrigerating Engineers)

HEAT CONDUCTIVITY

Miscellaneous insulating Materials

Material	Density #/cu. ft.	K Conductivity
Cork, granulated, impregnated with pitch	17.79	0.428
Balsa	7.05	0.32
Glass wool (Curled pyrex)	4.0	0.29
Mineral (slag) wool, loose packed	12.0	0.26
Rock wool (fibrous rock, also felted)	6.0	0.26
Sawdust, pine	1.56	0.57
Straw fibres, pressed	8.67	0.32
Wood fibres (kingia australis)	8.4	0.33
Wool, pure	4.99	0.26

Note: K = BTU/sq. ft./hr./°F. for a 1" thickness

(Courtesy of: American Society of Refrigerating Engineers)

CONDUCTIVITY OF PROPRIETARY MATERIALS

Trade Name	Density #/cu. ft.	K Conductivity
Armstrong's Corkboard	7.3	0.285
Celotex	13.2	0.31
Dry-Zero	1.0	0.24
Nu Wood	15.0	0.32
United's 100% pure Corkboard	9.0	0.27
U. S. Mineral Wool	12.0	0.26
Ferro Therm metal sheet (4 sheets)	4oz./□1/sheet	0.226

(Courtesy of: American Society of Refrigerating Engineers)

442. PREFERRED AMERICAN STORAGE PRACTICE:

Product	Temperature °F. for Short Storage	Temperature °F. for Long Storage
Apples	40	31–32
Asparagus	40	32–34
Bacon		
Fresh	38	0–5
Smoked	47	31–33
Beef	40	0
Butter	47	0–5
Celery	47	32–33
Cheese		
Swiss	40	38–40
American	40	34–35
Cream	42	31–32
Chocolate Candies	70	45–50
Corn (green)	45	32–33
Cucumbers	47	40
Eggs		
Crated	41	30–31
Fish		
Fresh	27	0
Frozen	25	0–10
Grapefruit	50	32–33
Grapes	40	31–32
Hams		
Fresh	38	0
Smoked	47	31–32
Lettuce	45	32–33
Iced	....	30–31
Oranges	50	32–33
Peaches	50	32–33
Pork		
Fresh	38	0
Pickled	43	31–32
Potatoes		
Irish	38	38–40
Sweet	57	.....
Poultry	30	—5 to —10 to freeze 0 to —5 to carry
Radishes	42	31–32
Turnips	42	31–32

(Courtesy of: American Society of Refrigerating Engineers)

443. MOTORS:

It is essential that electric motors for the successful operation of domestic refrigerating machines, and the smaller commercial installations have the following features: (*a*) ruggedness, reliability and uniformity of performance; (*b*) quietness and lack of vibration under starting and running conditions; (*c*) ability to start frequently and under conditions of low voltage, and to operate continuously at rated load with normal temperature rise; (*d*) low starting current; (*e*) high efficiency and power factor; (*f*) system of lubrication which requires infrequent attention; (*g*) non-interference with radio reception; (*h*) mechanical construction such that no current-carrying parts are exposed.

Direct Current Motors.

Direct current motors for the operation of refrigerating machines should be of the compound wound type. Sizes smaller than ½ H.P. may be started by switching directly across the line, but larger sizes are usually provided with current limiting starters that may be either of the manual or automatic type.

Alternating Current Motors.

Alternating current motors for operating domestic refrigerators are of the single-phase type, as polyphase distribution is seldom available at these installations; however, smaller commercial installations may permit the use of polyphase motors.

The single-phase motor of repulsion start induction type is well suited for this service, as it has high starting torque at comparatively low starting current. The capacitator motor, when provided with the necessary device for combining high starting torque with normal running performance, also meets the requirements.

The Ordinary Split-Phase Motor.

On account of the very high starting current required for sufficient starting torque, the ordinary split-phase motor is

suitable only for the operation of units requiring a small amount of power.

Standard D.C. voltages are 32, 115, and 230 volts. Standard A.C. voltages are 110 and 220 volts. Standard frequency in U. S. is 60 cycles. For the operation of electric refrigerators in locations where 30 or 60 cycles or D.C. is available, 1725 R.P.M. motors are used. Motors for operating on 25 or 50 cycle circuits have a speed of 1425 R.P.M. Motors for 40 cycle run at about 1150 R.P.M. Compensation for these reduced motor speeds is usually made in pulley sizes. Direct connected compressors must have ample displacement at the reduced speeds, or special compressors of greater displacement must be used with odd cycle motors.

The standard temperature guarantees of all motor parts when operating under normal rated conditions, as specified on the nameplate are (temperature rise; for open type motors 40°C.; for enclosed motors 55°C.).

The efficiency of small motors is only 50 per cent to 60 per cent; therefore they consume nearly twice as much current as they should theoretically. A ⅙ H.P. motor which should theoretically use only 124 watts or 1¼ amperes will be found to need approximately 2½ to 3 amperes.

CAPACITY AND POWER CONSUMPTION OF FOUR DOMESTIC REFRIGERATING UNITS WITH ¼ H. P. MOTOR
A and D Methyl Chloride; B and C Sulphur Dioxide.

			A		B		C		D	
Room Temperature	Inside Temperature	Dif.	Cap. lb./day	Power kw. hr./ton/day	Cap. lb./day	Power kw. hr./ton/day	Cap. lb./day	Power kw. hr./ton/day	Cap. lb./day	Power kw. hr./ton/day
90	50	40	297	74	116	116	95	144	94	168
80	45	35	337	64	116	106	95	133	104	136
70	42	28	336	65	104	92	119	112	123	108
90	55	35	282	80	147	102	104	127	80	166
80	50	30	310	78	171	98	110	125	98	138
70	45	25	334	66	161	96	102	122	100	136

(Courtesy of: American Society of Refrigerating Engineers)

MAXIMUM FUSE RATING FOR RUNNING PROTECTION (AMPERES)

H.P.	110 volt single-phase AC R.I. or capacitator motors	115 volt DC compound wound motors
1/8	4	3
1/6	4	3
1/4	6	4
1/3	8	6
1/2	10	8
3/4	15	10

(Courtesy of: American Society of Refrigerating Engineers)

444. WIRE SIZES:

NATIONAL BOARD OF FIRE UNDERWRITERS' WIRE RECOMMENDATIONS

Wire No.	Diameter of Wire in inches	Ampere Capacity	
		Rubber Insulated	Other Insulation
18	.040	3	5
16	.051	6	10
14	.064	15	20
12	.081	20	25
10	.102	25	30
8	.128	35	50
6	.162	50	70
4	.204	70	90
2	.258	90	125

445. SMALL COMPRESSOR PERFORMANCE SINGLE CYL. S.A. SO_2 AT 337 R.P.M.:

Discharge Pressure lb./□ in abs.	Vol. eff %	Capacity, lb./day	
		Suction 15.2 lb./□ in. abs.	Suction 18.2 lb./□ in. abs.
40	83.0	167.5	190
60	77.5	153.0	185
80	65.0	138.5	170
100	57.0	124.0	155
120	53.0	119.5	140
140	48.0	95.0	125
160	45.0	81.5	110

(Courtesy of: American Society of Refrigerating Engineers)

446. BRINE FREEZING TEMPERATURES:

ALCOHOL (Formula No. 1)

Temperature °F. (Freezing)	10°	0°	—10°	—20°
Specific Gravity at 60°F.	.9691	.9592	.9486	.9345

GLYCERIN

Temperature °F. (Freezing)	20°	10°	0°	—10°	—20°	—30°
Specific Gravity at 60°F.	1.056	1.082	1.105	1.123	1.137	1.151

CALCIUM CHLORIDE

Temperature °F. (Freezing)	20°	10°	0°	—10°	—20°
Specific Gravity at 60°F.	1.090	1.140	1.175	1.201	1.227

447. REFRIGERANT CONTROL CHARACTERISTICS:

The most difficult refrigerant control to understand is the thermostatic expansion valve. The following is a brief explanation of its operation.

The thermostatic expansion valve works on the pressure difference basis; that is, the pressure difference between the element bellows and the body sealing bellows. With the unit running, the refrigerant in the expansion valve thermostatic element is usually about 10°F. warmer than the refrigerant in the cooling coil producing the different pressures. This means that the unit pressure in the element is greater than the unit pressure in the cooling coils (both containers using the same refrigerant). Therefore, to obtain balanced total pressures between the two bellows, the element control bellows has a smaller area (diameter) than the sealing bellows. This temperature (pressure) difference means that the element maintains a superheat over the coils refrigerant temperature while the unit is running.

When the compressor stops, the low side pressure and the element pressure tend to equalize. The total expansion valve bellows pressure therefore overpowers the element bellows pressure and the needle is forced firmly into the seat

stopping the flow of refrigerant. The needle will now stay closed until the element pressure builds up enough to overcome the low side pressure. This can only happen when the

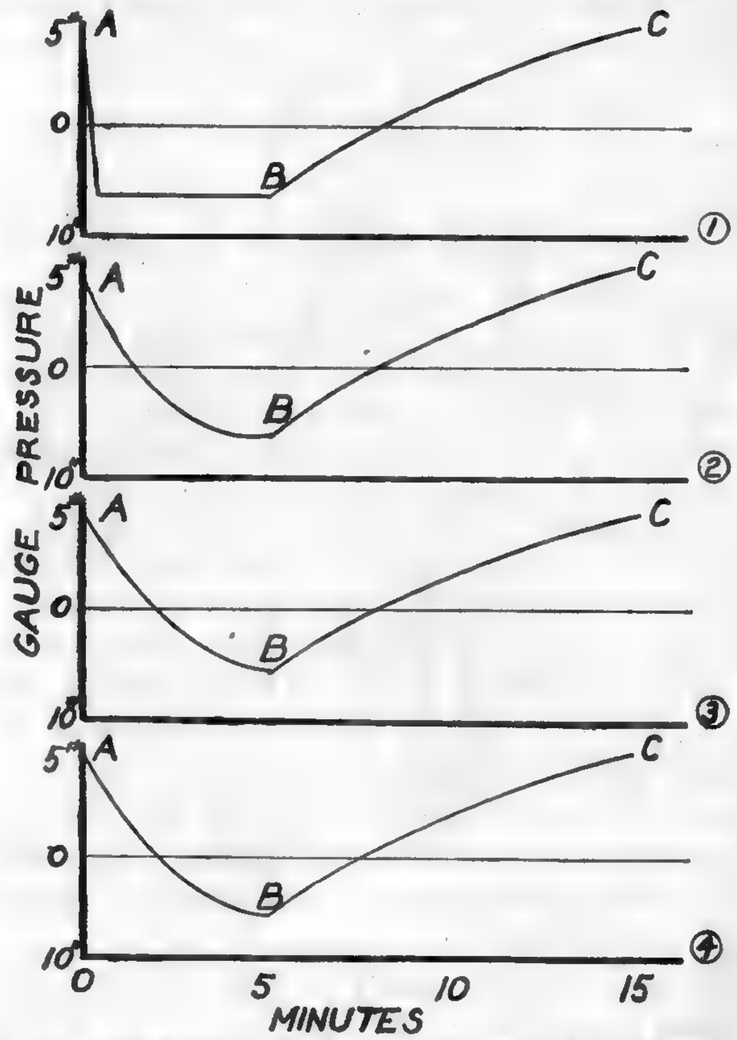


Fig. 318. Low side pressure time graphs for various refrigerant controls 1. Expansion valve (pressure); 2. Low side float; 3. High side float; 4. Thermostatic expansion valve; A. Cut-in point; B. Cut-out point; C. cut-in point

unit is running. This prevents the flooding of the low side while the compressor is idle if the valve is adjusted correctly.

With the adjustment turned out one or two revolutions, while the unit is running, the needle will close even though there is a greater temperature difference (about 15°F. temperature difference) between the refrigerant in the coil and that in the bulb. The refrigerant liquid will not reach the bulb location in this case because the low pressure gas only will be cold enough to reduce the element pressure to the closing point. The coil will then be starved and the needle will shut off before the coil becomes full of liquid refrigerant. When the adjustment is turned in one or two revolutions, it means that the temperature of the element refrigerant must become more near that of the cooling coil refrigerant (8°F. to 9°F.). The coil must now become more than full of liquid refrigerant to bring the temperature (pressure) difference down to this value and the coil will be completely flooded and may even frost the suction line. This adjustment is sensitive and should never be turned more than one-quarter of a turn at a time. Some thermostatic expansion valves use diaphragms of equal diameter instead of bellows. However, in this case, the valve is closed when the unit is idle by means of springs working in favor of the low-side pressure pressing on one side and the element pressure on the other side. Figure 313 illustrates the low-side pressure behavior when the various refrigerant controls are used.

A simple method of testing thermostatic expansion valves in the field recommended by the Detroit Lubricator Company is as follows:

In most cases the regular service kit contains all of the necessary equipment. The equipment required is as follows:

1. Service drum full of Freon or Methyl Chloride (in the shop a supply of clean dry air at 75 to 100 pounds pressure can be used in place of the service drum). The service drum is merely for the purpose of supplying pressure

and for this reason the refrigerant used does not have to conform with the valve being tested: in other words, a drum of Freon would be perfectly satisfactory for testing with SO_2, Methyl Chloride or Freon valves.

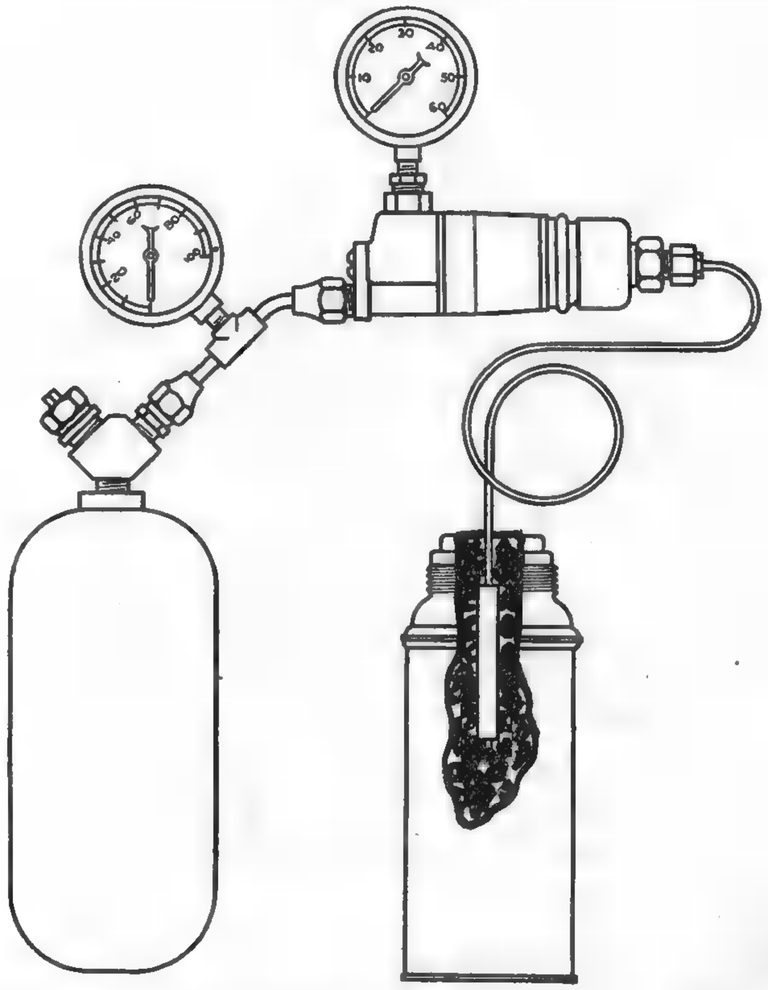


Fig. 313A. A method of testing the thermostatic expansion valve

2. A high pressure and low pressure gauge. The low pressure gauge should be accurate and should be in good condition so that the pointer does not have too much lost

motion. The high pressure gauge is not absolutely necessary but is recommended so as to show the pressure on the inlet of the valve.

3. Fittings and connections are required to complete the hook up as shown in Figure 313A.

4. A small quantity of finely crushed ice is necessary and one of the most convenient ways of carrying this around is to keep it in a thermos bottle. These thermos bottles are now available with a large size neck. If such a container is completely filled with crushed ice it will last easily for twenty-four hours. Whatever the container is, it should be completely filled with crushed ice. Do not attempt to make this test with the container full of water and a little crushed ice floating around on the top.

Proceed as follows to adjust the valve.

1. Connect the valve up as shown with the low pressure gauge screwed loosely into the adapter on the expansion valve outlet. The gauge is screwed up loosely so as to provide a small amount of leakage through the threads.

2. Insert the bulb in the crushed ice.

3. Open the valve on the service drum and be sure that the drum is warm enough to build up a pressure of at least 70 pounds on the high pressure gauge connected in the line to the valve inlet.

4. The expansion valve can now be adjusted. The pressure on the outlet gauge should be different for various refrigerants as follows:

Freon	22 pounds
Methyl Chloride	15 pounds
Sulphur Dioxide	3 pounds

In making the adjustment, be sure to have a small amount of leakage through the gauge connection.

5. Tap the body of the valve lightly in order to determine if the valve is smooth in operation. The needle of the gauge should not jump more than 1 pound.

To test the needle for leaks, screw the gauge up tight so as to stop the leakage through the threads and determine if the expansion valve closes off tightly. With a good valve the pressure will increase a few pounds and then either stop or build up very slowly. With a leaking valve the pressure will build up rapidly until it equals the inlet pressure.

The power element may be tested by loosening the gauge so as to permit leakage through the threads and then removing the feeler bulb from the crushed ice and warming it up with your hand or by putting it in water at about room temperature. The pressure should increase rapidly showing that the power element has not lost its charge. If the pressure does not increase when this is done, it is a sign that the power element is dead.

Note: With the new gas charged expansion valves, the amount of charge in the power element is limited and the pressure will not build up above the specified pressure. This pressure is always marked on the power element and must be considered when testing gas charged valves.

The body bellows is tested with high pressure showing on both gauges as outlined in the preceding paragraph. A leak is detected by loosening up the packing nut and using a Halide leak detector to detect the escape of gas. When making this test it is important that the body of the valve have a fairly high pressure on it and also that the gauge and other fittings are screwed up tight so as

to eliminate leakage at other points. Leakage can also be detected by the use of oil or soap suds.

448. THERMOGRAPHS:

To relieve any possibility of doubt as to the operation of the refrigerator after it has been installed, in trouble shooting, or after complaints from the owner, it is always advisable to install a thermograph of one type or another to

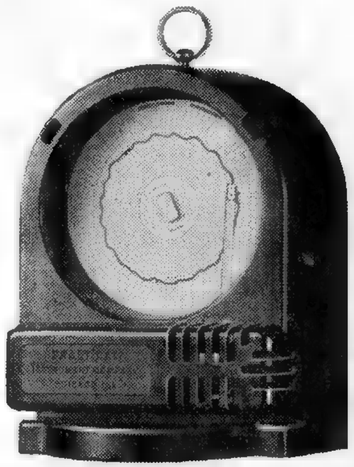


Fig. 314. Time-temperature recorder or thermograph
(Courtesy of: Practical Instruments Company)

obtain an accurate record of the operation. Most thermographs are of the type that have a clock dial graph and record the temperatures of the box during the period of 24 hours, or 7 days. Figure 314.

Another type is an operating-time recorder, which will indicate on a dial card the number of hours of operation of the electric motor during twenty-four hours or seven days. Figure 315. These records are an excellent means of checking refrigerators, and are the only accurate ones that are easily transferable.

Another type of thermograph or time temperature recorder is the cylindrical type illustrated in Figure 316.

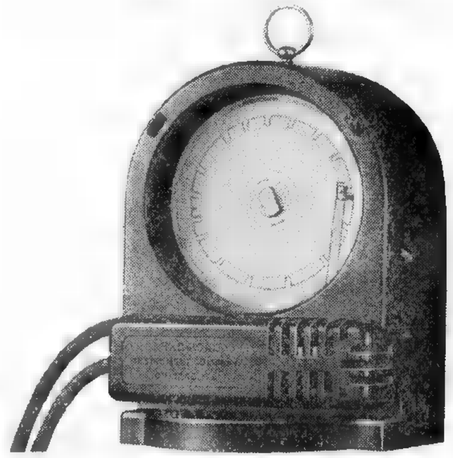


Fig. 315. A device for recording the time and length of time an electric refrigerator operates during 24 hours
(Courtesy of: Practical Instruments Company)

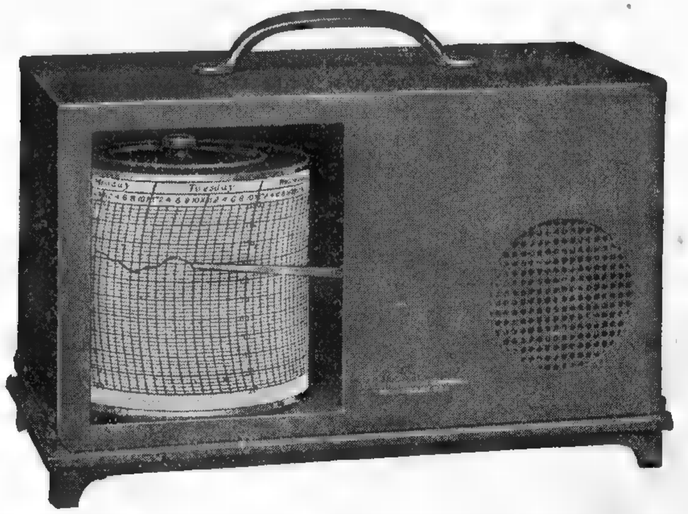


Fig. 316. Thermograph for recording the operation of a refrigerator during a week's period
(Courtesy of: Taylor Instrument Company)

These instruments vary in cost from about $30 to $100 depending upon their size and accuracy. The recording is usually accomplished with an inked pen, using red ink. The cost of these instruments usually prohibits their use except by very well established large companies.

However, smaller service stations may use a substitute which, although it does not work as well, is better than relying upon the customer's opinion. This method is to use an electric clock; install it in the electrical circuit so that the clock will run only when the electric motor is running. In other words, attach it across the electric motor between the electric motor and the thermostat, i.e., in parallel with the motor. This type of recording will indicate the total time that the electric motor operates during a certain period; this time will vary as the refrigerator goes out of adjustment or becomes old and worn out.

The length of time of operating will vary with the type of installation, but a typical domestic installation will run approximately one-third of the time if it is in good condition.

449. BELT TENSIONS AND ALIGNMENTS:

Up to the present time about 90 per cent of the mechanical refrigerators are equipped with V-type belts. It is imperative that when installing these belts one be very careful to adjust for proper belt tension and also for alignment. The proper belt tension is secured when the belt will have about one inch play. That is, the belt should be loose enough to move out of its original line about one inch. The compressor flywheel and the electric motor pulley must be in line with each in two different ways to give long life to the belt and to the electric motor. First, the center line of the compressor must be parallel with the center line of the electric motor shaft; second, the pulley grooves must be in line

with each other to enable the belt to run freely in them. The reason a poorly aligned belt will decrease the life of the electric motor is because the motor is not designed to stand an end load, and a noisy, poorly operating motor will result.

450. LIVE WIRE ELECTRICAL CONNECTIONS:

In making electrical connections to a domestic refrigerator, it is always preferred that the thermostat which is installed in the circuit be hooked across or in the live wire line of the circuit. This live wire in the alternating current circuit is easily recognized by the fact that if a trouble lamp were hooked to one of the lines and then grounded to a very good ground, the lamp would light if that particular wire happened to be the live wire of the two.

The other wire is called the ground wire of the circuit and it should be run directly to the motor. If a trouble lamp is not available, an AC voltmeter will serve the same purpose.

451. ENERGY REQUIRED FOR DOMESTIC REFRIGERATOR:

HERMETICALLY SEALED MACHINE, INSTALLED IN CABINET

Motor Size H.P.	Normal Input Watts	Inside Volume, Cabinet Ft.	Ice Melting Capacity, lb./day
1/10	145	4	50
1/8	160	5.5	70
1/8	160	6	70
1/6	200	5.5	92
1/6	200	7.5	92
1/6	200	10	112
1/6	200	13	112
1/6	200	17	112
1/3	340	13	200
1/3	340	17	200
1/2	475	..	333

(Courtesy of: American Society of Refrigerating Engineers)

CAPACITY AND ROOM TEMPERATURE
(Average for Actual Refrigerators in Use)

Room Temperature °F.	Relative Ice Melting Capacity
60	140
70	105
80	100
90	95
100	89
110	84

(Courtesy of: American Society of Refrigerating Engineers)

AVERAGE ELECTRIC LOAD FROM 1000 HOMES WITH REFRIGERATORS (Watts/House)

Time of Day	Refrigerator Watts	Lighting Watts
Noon	58	38
2:00 P. M.	62	40
4:00	62	48
6:00	62	156
8:00	66	154
10:00	60	104
Midnight	64	30
2:00 A. M.	56	8
4:00	54	8
6:00	52	46
8:00	54	78
10:00	54	58
Average Load	59	63
Daily Load Factor	87	38
Time of Year	**Refrigerator kw. hr./month**	**Lighting kw. hr./month**
January	34	63
February	40	56
March	42	50
April	46	48
May	46	42
June	46	38
July	55	37
August	56	36
September	53	42
October	52	48
November	43	52
December	39	58
Total	542	570

(Courtesy of: American Society of Refrigerating Engineers)

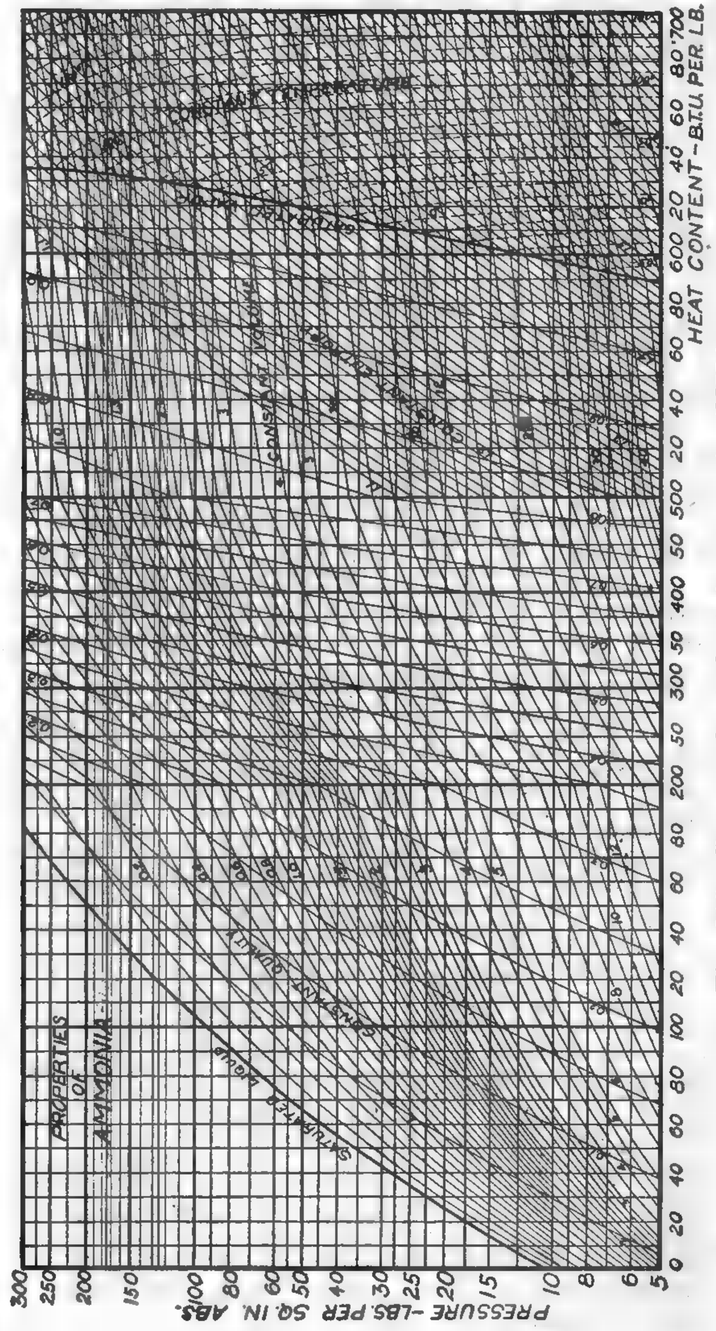


Fig. 317. Pressure-heat chart for ammonia (NH_3)
(Courtesy of: American Society of Refrigerating Engineers)

452. REFRIGERANT TABLES AND GRAPHS:

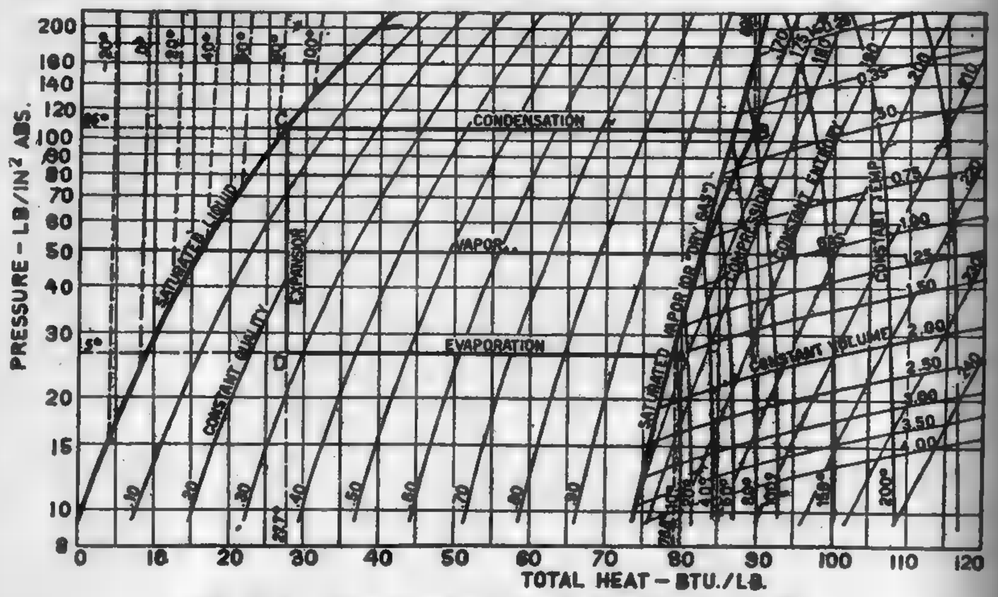


Fig. 318. Pressure-heat chart for Freon (F-12)
(Courtesy of: American Society of Refrigerating Engineers)

(1) AMMONIA

Temp. ° F.	Pressure Lb./□″ Gauge	Pressure Lb./□″ Abs.	Volume Gas Cu. ft./lb.	Density Liquid Lb./cu. ft.	Heat Content B.T.U./lb. Liquid	Heat Content B.T.U./lb. Latent
−40	8.7″	10.41	24.86	43.1	0.0	597.6
−30	1.6″	13.90	18.97	42.65	10.7	590.7
−20	3.6	18.30	14.68	42.2	21.4	583.6
−10	9.0	23.74	11.50	41.8	32.1	576.4
−6	15.7	30.42	9.116	41.3	42.9	568.9
5	19.6	34.27	8.150	41.15	48.3	565.0
10	23.8	38.51	7.304	40.85	53.8	561.1
20	33.5	48.21	5.910	40.4	64.7	553.1
30	45.0	59.74	4.825	39.9	75.7	544.8
40	58.6	73.32	3.971	39.45	86.8	536.2
50	74.5	89.19	3.294	38.96	97.9	527.3
60	92.9	107.6	2 751	38.5	109.2	518.1
70	114.1	128.8	2.312	38.0	120.5	508.6
80	138.3	153.0	1.955	37.45	132.0	498.7
86	154.5	169.2	1.772	37.16	138.9	492.6
90	165.9	180.6	1.661	36.9	143.5	488.5
100	197.2	211.9	1.419	36.35	155.2	477.8
110	231.3	247.0	1.217	35.85	167.0	466.7
120	271.7	286.4	1.047	35.25	179.0	455.0
125	293.1	307.8	.973	.....	185.1	488.9

(2) FREON

Temp. ° F.	Pressure Lb./□″ Gauge	Pressure Lb./□″ Abs.	Volume Gas Cu. ft./lb.	Density Liquid Lb./cu. ft.	Heat Content B.T.U./lb. Liquid	Heat Content B.T.U./lb. Latent
−40	10.92″	9.32	3.911	94.58	0	73.50
−30	3.26	12.02	3.088	93.59	2.03	72.67
−20	.58	15.28	2.474	92.58	4.07	71.80
−10	4.50	19.20	2.003	91.57	6.14	70.91
0	9.17	23.87	1.637	90.52	8.25	69.96
5	11.81	26.51	1.485	90.00	9.32	69.47
10	14.65	29.35	1.351	89.45	10.39	68.97
20	21.05	35.75	1.121	88.37	12.55	67.94
30	28.46	43.16	0.939	87.24	14.76	66.85
40	36.98	51.68	0.792	86.10	17.00	65.71
50	46.69	61.39	0.673	84.94	19.27	64.51
60	57.71	72.41	0.575	83.78	21.57	63.25
70	70.12	84.82	0.493	82.60	[illegible].90	61.92
80	84.06	98.76	0.425	81.38	26.28	60.52
86	93.2	107.9	0.389	80.63	27.72	59.65
90	99.6	114.3	0.368	80.11	28.70	59.04
100	116.9	131.6	0.319	78.80	31.16	57.46
110	136.0	150.7	0.277	77.46	33.65	55.78
120	157.1	171.8	0.240	76.02	36.16	53.99
130	180.2	194.9	0.208	74.46	38.69	52.07
140	205.5	220.2	0.180	72.73	41.24	50.00

452A. REPLACING FREON WITH METHYL CHLORIDE:

Due to the present (1943) difficulty in obtaining sufficient quantities of Freon, in some service operations it may be necessary to substitute some other refrigerant. Methyl chloride is the most frequently used substitute for Freon. Its use is only recommended in extreme cases of emergency and Freon (F-12) should be put back into the unit as soon as possible.

Do not put methyl chloride in Freon units that use aluminum gaskets. The conversion may be done in small domestic units without any changes, if automatic expansion valves or high side floats are used. If thermostatic ex-

pansion valves are used, they must be readjusted or replaced. The unit will run more of the time; however, the power consumption will not be much greater due to the lower head pressures. The cost of operation may be slightly increased.

Larger units may necessitate a larger motor pulley (25% increase in diameter) in order that the compressor may be speeded up to take care of the increased volume of gas. This increase in pulley size may demand a longer belt. Excessive compressor speeds should be avoided if possible.

(3) METHYL CHLORIDE

Temp. ° F.	Pressure		Volume Gas Cu. ft./lb.	Density Liquid Lb./cu. ft.	Heat Content B.T.U./lb.	
	Lb./□″ Gauge	Lb./□″ Abs.			Liquid	Latent
−40	15.9″	7.0	12.6	63.98	0	183.5
−30	11.9″	9.0	9.82	63.40	4	182
−20	6.9″	11.5	8.09	62.77	7.2	181.8
−10	.05″	15.0	6.46	62.17	11.0	180.5
− 0	3.8	18.5	5.18	61.51	14.5	179.5
5	6.19	20.89	4.65	61.20	16.3	179.0
10	8.6	23.3	4.18	60.89	18.0	178.5
20	13.6	28.3	3.41	60.23	21.7	177.3
30	20.3	35.0	2.81	59.62	25.2	176.0
40	28.1	42.8	2.31	58.96	28.9	174.8
50	36.3	51.0	1.93	58.15	32.5	172.8
60	46.3	61.0	1.61	57.62	36.5	170.5
70	57.8	72.5	1.34	56.91	40.5	167.5
80	72.3	87.0	1.14	56.22	44.5	164.5
86	80.83	95.53	1.06	55.77	46.5	163.0
90	87.3	102.0	0.98	55.53	48.0	162.0
100	102.3	117.0	0.85	54.84	52.0	158.5
110	118.3	133.0	0.765	54.12	55.5	155.2
120	139.3	154.0	0.700	53.936	59.0	152
130	161.3	176.0	580	.....	62.5	148.8
140	185.3	200.0	.514	.....	67.0	144
150	213.3	228.0	.453	.....	71.0	139.6
160	243.3	258.0	388	.....	75.5	134.5

(4) SULPHUR DIOXIDE

Temp. ° F.	Pressure		Volume Gas Cu. ft./lb.	Density Liquid Lb./cu. ft.	Heat Content B.T.U./lb.	
	Lb./□″ Gauge	Lb./□″ Abs.			Liquid	Latent
−40	23.54″	3.136	22.42	95.79	0.00	178.61
−30	21.10″	4.331	16.56	94.94	2.93	176.97
−20	17.93″	5.883	12.42	94.10	5.98	175.09
−10	13.91″	7.863	9.44	93.27	9.16	172.97
0	8.85″	10.35	7.28	92.45	12.44	170.63
5	5.87″	11.81	6.421	92.00	14.11	169.38
10	2.59″	13.42	5.682	91.58	15.80	168.07
20	2.48	17.18	4.487	90.71	19.20	165.32
30	7.00	21.70	3.581	89.76	22.64	162.38
40	12.40	27.10	2.887	88.81	26.12	159.25
50	18.75	33.45	2.348	87.87	29.61	155.95
60	26.23	40.93	1.926	86.95	33.10	152.49
70	34.92	49.62	1.590	86.02	36.58	148.88
80	44.98	59.68	1.321	85.03	40.05	145.12
86	51.75	66.45	1.185	84.44	42.12	142.80
90	56.55	71.25	1.104	84.05	43.50	141.22
100	69.82	84.52	.9262	83.07	46.90	137.20
110	85.06	99.76	.7804	82.03	50.26	133.05
120	106.23	120.93	.6598	80.90	53.58	128.78
130	121.78	136.48	.5595	79.81	56.85	124.39
140	143 91	158.61	.4758	78.61	60 04	119.90

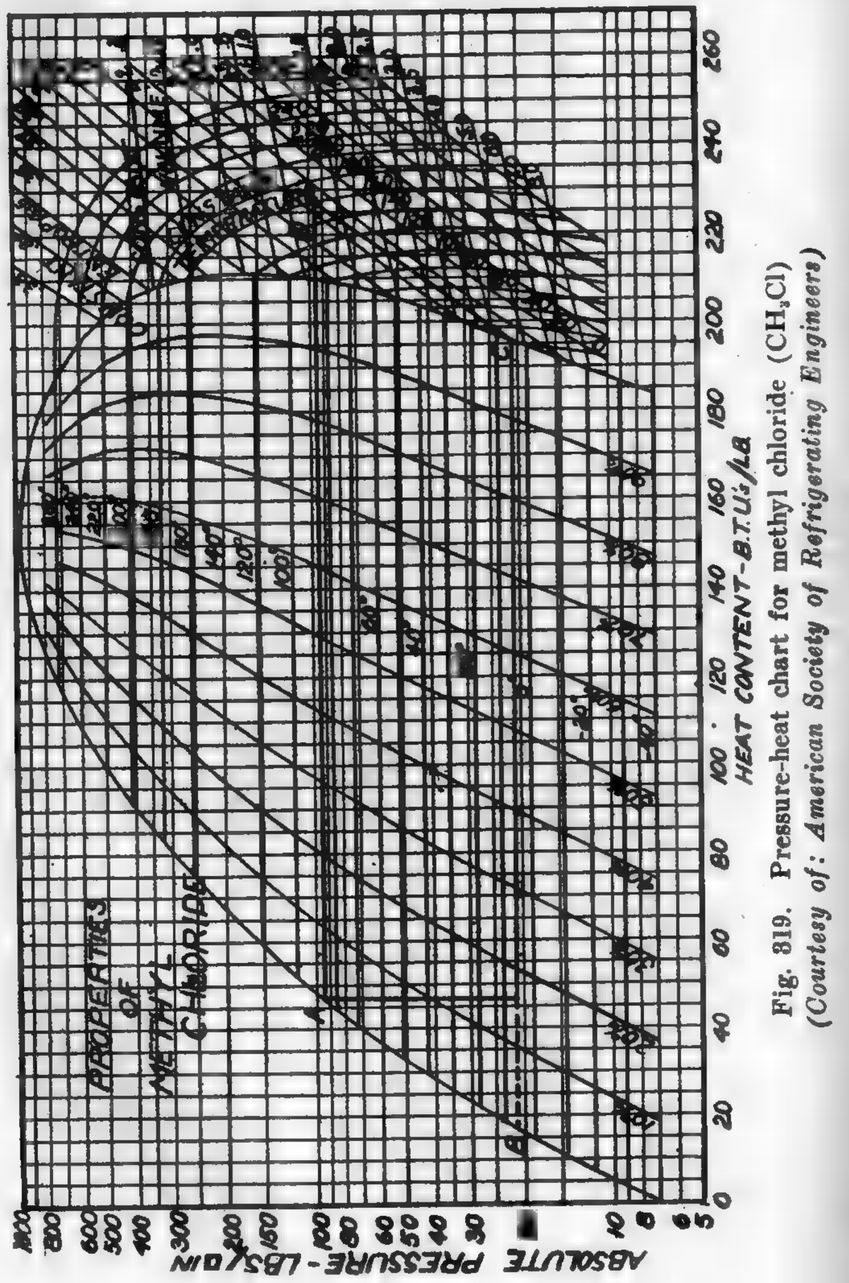


Fig. 319. Pressure-heat chart for methyl chloride (CH_3Cl)
(Courtesy of: American Society of Refrigerating Engineers)

453. AMERICAN STANDARD SAFETY CODE FOR MECHANICAL REFRIGERATION (1939):

SECTION II

DEFINITIONS

2.10 Approved—Acceptable to the authorities having jurisdiction.

2.11 Brazed Joint—For the purpose of this Code, a brazed joint is a gas-tight joint, obtained by the joining of metal parts with alloys which melt at temperatures higher than 1000 F. but less than the melting temperatures of the joined parts.

2.12 Brine—Any liquid, used for the transmission of heat without a change in its state, having no flash point or a flash point above 150 F. determined by American Society for Testing Materials method D56-36.

2.13 Compressor—A mechanical device used in a Refrigerating System for the purpose of increasing the pressure upon the refrigerant.

2.14 Condenser—A vessel or arrangement of pipe or tubing in which vaporized refrigerant is liquefied by the removal of heat.

2.15 Condensing Unit—A specific refrigerating machine combination consisting of a motor-driven compressor, a condenser, a liquid receiver, and the regularly furnished accessories.

2.16 Container—A cylinder for the transportation of refrigerant constructed to conform to the Specifications of the Interstate Commerce Commission as contained in their "Regulations for the Transportation by Rail of Explosives and other Dangerous Articles in Freight, Express and Baggage Services, including Specifications for Shipping Containers" effective October 1, 1930, with supplements 1 to 18 inclusive.

2.17 Department Store—The entire space occupied by one tenant or more than one tenant in an individual store where more than 100 persons commonly assemble on other than the street level floor for the purpose of buying personal wearables and other merchandise used in the home.

2.18 Design Working Pressure—The maximum allowable working pressure for which a vessel is designed.

2.19 Duct—A tube or conduit used for conveying air.

2.20 Evaporator—That part of the system in which liquid refrigerant is vaporized to produce refrigeration.

2.21 Expansion Coil—An evaporator constructed of pipe or tubing.

2.22 Fusible Plug—A device having a predetermined temperature fusible member for the relief of pressure.

2.23 Generator—Any device equipped with a heating element used in the Refrigerating System to increase the pressure of the refrigerant in its gas or vapor state for the purpose of liquefying the refrigerant.

2.24 Liquid Receiver—A vessel permanently connected to a system by inlet and outlet pipes for storage of a liquid refrigerant.

2.25 Machinery—Refrigerating equipment including any or all of the following: compressor, condenser, generator, absorber, receiver, connecting pipe, evaporator, or complete Unit System.

2.26 Machinery Room—A room in which is permanently installed and operated a Refrigerating System but not including evaporators located in a cold storage room, refrigerator box, air cooled space, or other enclosed space. Closets solely contained within and opening only into a room shall be considered a part of such room.

2.27 Machinery Room, Class T—A room having machinery other than flame producing apparatus permanently installed and operated and also having:

(a) Doors which are tight-fitting, fire-resisting, and self-closing.

(b) Walls which are vapor-tight and of approved fire resistive construction.

(c) An exit door which opens directly to the outer air or through a vestibule-type exit equipped with self-closing, tight-fitting doors.

(d) Exterior openings which, if present, are not under any fire escape or any open stairway.

(e) All pipes piercing the interior walls or floor of such room, tightly sealed to the walls or floor through which they pass.

(f) Emergency remote controls located immediately outside to stop the action of the refrigerant compressor.

(g) Mechanical means for ventilation.

(h) Emergency remote controls for the mechanical means of ventilation located outside.

2.28 Mechanical Joint—For the purpose of this Code, a mechanical joint is a gas-tight joint, obtained by the joining of metal parts through a positive-holding mechanical construction.

2.29 Piping—Pipe or tube mains for interconnecting the various parts of a Refrigerating System.

2.30 Pressure Limiting Device—A pressure responsive mechanism designed to automatically stop the operation of the compressor at a predetermined pressure.

2.31 Pressure Relief Device—A valve or rupture member designed to automatically relieve excessive pressure.

2.32 Pressure Relief Valve—A valve held closed by a spring or other means and designed to automatically relieve pressure in excess of its setting.

2.33 Pressure Vessel—Any refrigerant containing receptacle of a Refrigerating System other than expansion coils, headers, and pipe connections.

2.34 Refrigerant—A substance used to produce refrigeration by its expansion or vaporization.

2.35 Refrigerating System—A combination of interconnected refrigerant containing parts in which a refrigerant is circulated for the purpose of extracting heat.

2.36 Rupture Member—A device that will automatically rupture at a predetermined pressure.

2.37 Soldered Joint—For the purpose of this Code, a soldered joint is a gas-tight joint, obtained by the joining of metal parts

with metallic mixtures or alloys which melt at temperatures below 1000 F. and above 350 F.

2.38 Stop Valve—A shut-off for controlling the flow of refrigerant.

2.39 Tenant—As herein used a tenant shall be construed as a person, firm, or corporation possessed with the legal right to occupy premises.

2.40 Welded Joint—For the purpose of this Code, a welded joint is a gas-tight joint, obtained by the joining of metal parts in the plastic or molten state. (Abbreviated from American Standards Association Code for Pressure Piping, B31.1—1935.)

SECTION III

BUILDING OCCUPANCY CLASSIFICATION

3.10 Locations in which Refrigerating Systems may be placed are grouped by occupancy as follows:

3.20 Institutional occupancy shall apply to that portion of a building in which persons are harbored to receive medical, charitable, educational, or other care or treatment, or in which persons are held or detained by reason of public or civic duty, including among others, hospitals, asylums, sanitariums, police stations, jails, court houses with cells, and similar occupancies.

3.30 Public Assembly occupancy shall apply to that portion of the premises in which persons congregate for civic, political, educational, religious, social, or recreational purposes; including among others, auditoriums, assembly rooms, armories, ball rooms, bath houses, broadcasting studios, colleges, court houses without cells, churches, dance halls, department stores, exhibition halls, fraternity halls, lodge rooms, mortuary chapels, museums, schools, libraries, passenger depots, subway stations, bus terminals, theatres, skating rinks, and similar occupancies.

3.40 Residential occupancy shall apply to that portion of a building in which sleeping accommodations are provided for more than two families, including among others, multiple story apartments, tenements, hotels, lodging houses, dormitories, convents, studios, club houses, and similar occupancies.

3.50 Commercial occupancy shall apply to that portion of a building used for the transaction of business; for the rendering of professional services; for the supplying of food, drink, or other bodily needs and comforts; for manufacturing purposes or for the performance of work or labor, except as included under "Industrial" occupancies, including among others, office buildings, professional buildings, markets, restaurants, laboratories, bake shops, fur storage, loft buildings, stores other than department stores, and similar occupancies.

3.60 Industrial occupancy shall apply to an entire building when used by a single tenant for manufacturing, processing, or storage of materials or products, including among others, chemical, food, candy and ice cream factories, ice making plants, meat packing plants, refineries, perishable food warehouses, and similar occupancies, where a single tenant is defined as a single authority which operates and maintains the entire building and the Refrigerating System.

3.70 Mixed occupancy shall apply to a building occupied or used for different purposes in different parts. When the occupancies are cut off from the rest of the building by tight partitions, floors and ceilings and protected by self-closing doors, the requirements for each type of occupancy shall apply for its portion of the building. When the occupancies are not so separated, the occupancy carrying the more stringent requirements shall govern.

SECTION IV

REFRIGERATING SYSTEM CLASSIFICATION BY TYPE

4.10 Refrigerating Systems shall be divided into classes, descriptive of the method employed for extracting heat as follows:

4.20 Direct System is one in which the evaporator is in direct contact with the material or space refrigerated or is located in air circulating passages communicating with such spaces.

4.30 Unit System is one which has been assembled and tested prior to its installation and which is installed without connecting any refrigerant containing parts.

4.40 Indirect System is one in which a liquid, such as brine or water, cooled by the refrigerant, is circulated to the material or space refrigerated or is used to cool air so circulated. Indirect Systems which are distinguished by the type or method of application are as follows:

4.41 Indirect Open Spray System is one in which ■ liquid, such as brine or water, cooled by an evaporator located in an enclosure external to ■ cooling chamber, is circulated to such cooling chamber and is sprayed therein.

4.42 Indirect Closed Surface System is one in which a liquid, such as brine or water, cooled by an evaporator located in an enclosure external to a cooling chamber, is circulated to and through such a cooling chamber in pipes or other closed circuits.

4.43 Indirect Vented Closed Surface System is one in which ■ liquid, such as brine or water, cooled by an evaporator located in ■ vented enclosure external to ■ cooling chamber, is circulated to and through such cooling chamber in pipes or other closed circuits.

4.44 Double Indirect Vented Open Spray System is one in which a liquid, such as brine or water, cooled by an evaporator located in ■ vented enclosure, is circulated through a closed circuit to ■ second enclosure where it cools another supply of a liquid, such as brine or water, and this liquid in turn is circulated to a cooling chamber and is sprayed therein.

4.45 Indirect Absorptive Brine System is an Indirect Vented Open Spray System in which the brine will chemically absorb the refrigerant in the system, and the chemical compound so formed in the solution will be stable at temperatures up to 100 F. The brine shall be of such quantity and concentration that it will absorb twice the total quantity of refrigerant in the system. An approved automatic device shall be provided for shutting down the system when the brine concentration becomes such that the

brine will absorb only one and one-half times the total quantity of refrigerant in the system.

4.46 Double Refrigerant System is one in which a refrigerant is used in the secondary circuit instead of brine or water. For the purpose of this Code, each circuit shall be considered as a separate Direct Refrigerating System.

4.50 The Direct and various Indirect Systems referred to above are illustrated in Fig. 1.

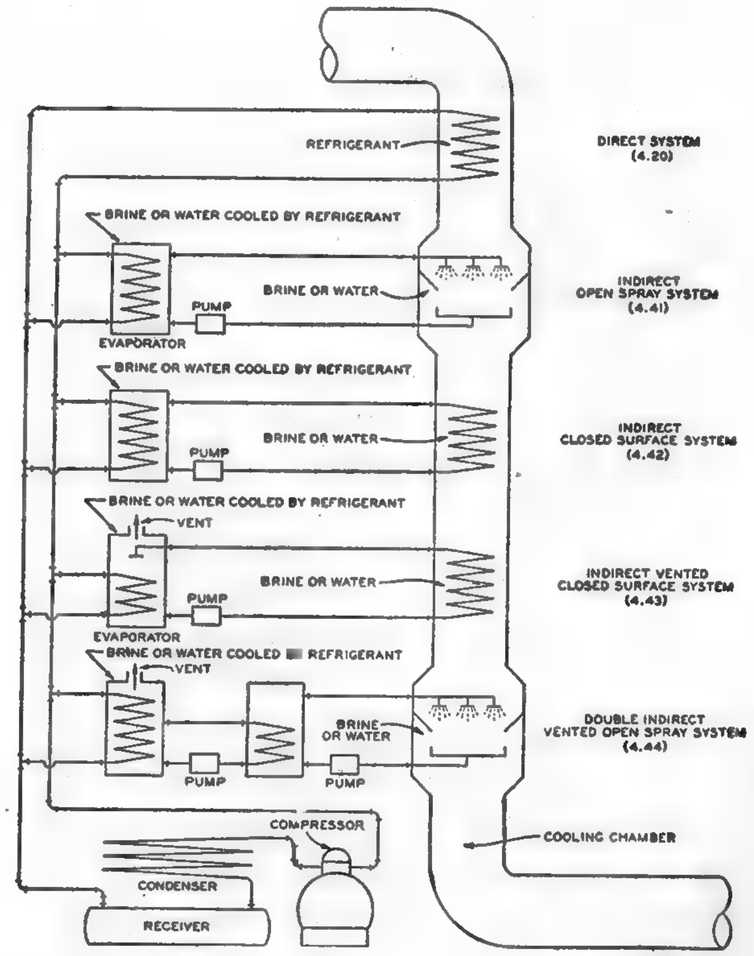


Fig. 1

SECTION V

REFRIGERANT CLASSIFICATION

5.10 Refrigerants shall, for Safety Code Purposes, be divided into groups as follows:

5.11 Group 1

	Chemical Formula
Carbon dioxide	CO_2
Dichlorodifluoromethane (Freon-12)	CCl_2F_2
Dichloromonofluoromethane (Freon-21)	$CHCl_2F$
Dichlorotetrafluoroethane (Freon-114)	$C_2Cl_2F_4$
Dichloromethane (Carrene No. 1) (Methylene chloride)	CH_2Cl_2
Trichloromonofluoromethane (Freon-11) (Carrene No. 2)	CCl_3F

5.12 Group 2

Ammonia	NH_3
Dichloroethylene	$C_2H_2Cl_2$
Ethyl chloride	C_2H_5Cl
Methyl chloride	CH_3Cl
Methyl formate	$HCOOCH_3$
Sulphur dioxide	SO_2

5.13 Group 3

Butane	C_4H_{10}
Ethane	C_2H_6
Isobutane	$(CH_3)_3CH$
Propane	C_3H_8

SECTION VI

INSTITUTIONAL OCCUPANCIES

General

6.10 No Refrigerating System shall be installed in or on public stairways, hallways, lobbies, entrances or exits.

6.11 Refrigerant piping or tubing shall not be carried through floors except that for the purpose of connecting to a condenser on the roof, it may be carried through a continuous, rigid and tight fire-resisting (four (4) hour rating) flue or shaft having no openings on intermediate floors, or it may be carried on the outer wall of the building provided it is not located in an air shaft,

closed court or in other similar open spaces enclosed within the outer walls of the building.

Group 1 Refrigerants

6.20 No Refrigerating System shall be installed in any room except Unit Systems each containing not more than ten (10) pounds of a Group 1 refrigerant, and then only when a window or other ventilation is provided, and except as otherwise permitted.

6.21 Systems each containing not more than twenty (20) pounds of a Group 1 refrigerant may be installed in kitchens, laboratories, and mortuaries.

6.22 Systems each containing more than twenty (20) pounds of a Group 1 refrigerant shall be of the Indirect type with all refrigerant containing parts, excepting parts installed outside the building, installed in a machinery room, used for no other purpose and in which for Group 1 refrigerants, excepting carbon dioxide, no flame is present or apparatus to produce a flame is installed.

6.23 When a Group 1 refrigerant, other than carbon dioxide, is used in a system any portion of which is in a room where there is an apparatus for producing an open flame, then such refrigerant shall be classed in Group 2 unless the flame producing apparatus is provided with a hood and flue capable of removing the products of combustion to the open air. Flames by matches, cigarette lighters, small alcohol lamps and similar devices, shall not be considered as open flames.

Group 2 Refrigerants

6.30 Group 2 refrigerants shall not be used except in Unit Systems containing not more than six (6) pounds of refrigerant when installed in kitchens, laboratories, or mortuaries, or except in systems containing not more than five hundred (500) pounds of refrigerant and having all refrigerant containing parts installed in a Class T machinery room.

6.31 Group 2 refrigerants shall not be used in ■ system for air conditioning for human comfort, except in an Indirect Vented Closed Surface System, or in a Double Indirect Vented Open Spray System, or in an Indirect Absorptive Brine System.

Group 3 Refrigerants

6.40 Group 3 refrigerants shall not be used in Institutional occupancies.

SECTION VII

PUBLIC ASSEMBLY OCCUPANCIES

General

7.10 No Refrigerating System shall be installed in or on public stairways, hallways, lobbies, entrances or exits.

7.11 Refrigerant piping or tubing shall not be carried through floors except from basements to the first floor or from the top floor to a penthouse or the roof, or except that for the purpose of connecting to a condenser on the roof it may be carried through a continuous, rigid and tight fire-resisting (four (4) hour rating) flue or shaft having no openings on intermediate floors, or it may be carried on the outer wall of the building provided it is not located in an air shaft, closed court or in other similar open spaces enclosed within the outer walls of the building.

Group 1 Refrigerants

7.20 The maximum quantity of a Group 1 refrigerant in a Direct System used for air conditioning for human comfort shall be limited by the volume of the space to be air conditioned as shown in the table at the top of the next column.

7.21 A system containing more than fifty (50) pounds of a Group 1 refrigerant, other than carbon dioxide, and which includes airducts shall be of the Indirect type unless it conforms to requirements as follows:

(a) Positive automatic fire damper or dampers shall be provided

to cut off the refrigerant containing apparatus from the duct system.

(b) Automatic means shall be provided to close the dampers and to stop the fan when the temperature of the air in the duct at the damper location reaches 210 F. when the damper is on the discharge side of a system containing ■ heating coil

Refrigerant		Maximum quantity in lbs. per 1000 cu. ft. of air conditioned space*
Name	Chemical Formula	
Carbon dioxide	CO_2	12
Dichlorodifluoromethane (Freon-12)	CCl_2F_2	30
Dichloromethane (Carrene No. 1)	CH_2Cl_2	6
Dichloromonofluoromethane (Freon-21)	$CHCl_2F$	13
Dichlorotetrafluoroethane (Freon-114)	$C_2Cl_2F_4$	40
Trichloromonofluoromethane (Freon-11)	CCl_3F	35

* NOTES

a. When the refrigerant containing parts of a system ■■ located in one or more enclosed spaces, the cubical contents of the smallest enclosed space other than the machinery room, shall be used to determine the permissible quantity of refrigerant in the system.

b. When the evaporator is located in a duct system, the cubical content of the smallest enclosed space served by the duct system shall be used to determine the permissible quantity of refrigerant in the system unless the air flow to any room served by the duct system cannot be reduced below ¼ of its maximum, in which case the cubical contents of the entire space served by the duct system shall be used to determine the permissible quantity of refrigerant in the system.

and at 125 F. when the damper is on the suction side of the system, or on the discharge side of ■ system containing no heating coil.

7.22 A system containing more than one thousand (1000) pounds of a Group 1 refrigerant shall be of the Indirect type with all the refrigerant containing parts, excepting parts mounted outside the building, installed in a machinery room used for no other purpose and in which for Group 1 refrigerants, excepting carbon dioxide, no flame is present or apparatus to produce a flame is installed.

7.23 When a Group 1 refrigerant, other than carbon dioxide, is used in a system, any portion of which is in ■ room where

there is an apparatus for producing an open flame, then such refrigerant shall be classed in Group 2 unless the flame producing apparatus is provided with a hood and flue capable of removing the products of combustion to the open air. Flames by matches, cigarette lighters, small alcohol lamps and similar devices, shall not be considered as open flames.

Group 2 Refrigerants

7.30 Group 2 refrigerants shall not be used except in Unit Systems containing not more than twelve (12) pounds of refrigerant, or except in systems containing not more than one thousand (1000) pounds of refrigerant and having all refrigerant containing parts installed in a Class T machinery room.

7.31 Group 2 refrigerants shall not be used in a system for air conditioning for human comfort, except in an Indirect Vented Closed Surface System, or in a Double Indirect Vented Open Spray System, or in an Indirect Absorptive Brine System.

Group 3 Refrigerants

7.40 Group 3 refrigerants shall not be used in Public Assembly occupancies.

SECTION VIII

RESIDENTIAL OCCUPANCIES

General

8.10 No Refrigerating System shall be installed in or on public stairways.

8.11 No Refrigerating System shall be installed in public hallways, lobbies, entrances, or exits, except Unit Systems containing not more than four (4) pounds of a refrigerant, provided free passage is not obstructed.

8.12 Refrigerant piping shall not be carried through floors except as follows:

(a) It may be carried from basements to the first floor or from the top floor to a penthouse or the roof.

(b) For the purpose of connecting to a condenser on the roof it may be carried through an approved, rigid and tight continuous fire-resisting flue or shaft having no openings on intermediate floors, or it may be carried on the outer wall of the building provided it is not located in an air shaft, closed court, or in other similar open spaces enclosed within the outer walls of the building.

(c) In systems containing Group 1 refrigerants and used for air conditioning for human comfort, the refrigerant piping may be carried through floors provided it is enclosed in an approved, rigid and tight continuous fire-resisting flue or shaft where it passes through any intermediate space not served by the air conditioning system. The flue shall be vented to the outside or to a space served by the air conditioning system. Such systems shall conform to the requirements of paragraph 8.20.

Group 1 Refrigerants

8.20 The maximum quantity of refrigerant in a Direct System used for air conditioning for human comfort, shall be limited by the volume of the space to be air conditioned as follows:

Refrigerant		Maximum quantity in lbs. per 1000 cu. ft. of air conditioned space*
Name	Chemical Formula	
Carbon dioxide	CO_2	12
Dichlorodifluoromethane (Freon-12)	CCl_2F_2	30
Dichloromethane (Carrene No. 1)	CH_2Cl_2	6
Dichloromonofluoromethane (Freon-21)	$CHCl_2F$	13
Dichlorotetrafluoroethane (Freon-114)	$C_2Cl_2F_4$	40
Trichloromonofluoromethane (Freon-11)	CCl_3F	35

* Notes

a. When the refrigerant containing parts of a system are located in two or more enclosed spaces, the cubical content of the smallest enclosed space other than the machinery room, shall be used to determine the permissible quantity of refrigerant in the system.

b. When the evaporator is located in a duct system, the cubical content of the smallest enclosed space served by the duct system shall be used to determine the permissible quantity of refrigerant in the system unless the air flow to any enclosed space served by the duct system cannot be reduced below ½ of its maximum, in which case the cubical contents of the entire space served by the duct system shall be used to determine the permissible quantity of refrigerant in the system.

8.21 A system containing more than fifty (50) pounds of a Group 1 refrigerant, other than carbon dioxide, and which includes air ducts shall be of the Indirect type unless it conforms to requirements as follows:

(a) Positive automatic fire damper or dampers shall be provided to cut off the refrigerant containing apparatus from the duct system.

(b) Automatic means shall be provided to close the dampers and to stop the fan when the temperature of the air in the duct at the damper location reaches 210 F. when the damper is on the discharge side of a system containing a heating coil and at 125 F. when the damper is on the suction side of the system, or on the discharge side of a system containing no heating coil.

8.22 A system containing more than one thousand (1000) pounds of a Group 1 refrigerant shall be of the Indirect type with all the refrigerant containing parts, excepting parts mounted outside the building, installed in ■ machinery room used for no other purpose and in which for Group 1 refrigerants, excepting carbon dioxide, no flame is present or apparatus to produce a flame is installed.

Group 2 Refrigerants

8.30 No system containing more than six (6) pounds of a Group 2 refrigerant shall be located in sleeping rooms, or spaces directly connected to sleeping rooms.

8.31 No system containing a Group 2 refrigerant shall be used for air conditioning for human comfort unless it is of the Indirect Vented Closed Surface, Double Indirect Vented Open Spray, Indirect Absorptive Brine, or primary circuit of a Double Refrigerant type with all the refrigerant containing parts, excepting parts mounted outside the building, installed in a machinery room used for no other purpose.

8.32 Any system containing more than three hundred (300) pounds of a Group 2 refrigerant shall have all refrigerant containing parts installed in ■ Class T machinery room.

Group 3 Refrigerants

8.40 Group 3 refrigerants shall not be used except in ■ Unit System containing not more than six (6) pounds of refrigerant.

SECTION IX

COMMERCIAL OCCUPANCIES

General

9.10 No Refrigerating System shall be installed in or on public stairways.

9.11 No Refrigerating System shall be installed in public hallways, lobbies, entrances, or exits, except Unit Systems containing not more than four (4) pounds of a refrigerant, provided free passage is not obstructed.

9.12 Refrigerant piping shall not be carried through floors except as follows:

(a) It may be carried from basements to the first floor or from the top floor to ■ penthouse or the roof.

(b) For the purpose of connecting to ■ condenser on the roof it may be carried through an approved, rigid and tight continuous fire-resisting flue or shaft having no openings on intermediate floors, or it may be carried on the outer wall of the building provided it is not located in an air shaft, closed court, or in other similar open spaces enclosed within the outer walls of the building.

(c) In systems containing Group 1 refrigerants and used for air conditioning for human comfort, the refrigerant piping may be carried through floors provided it is enclosed in an approved, rigid and tight continuous fire-resisting flue or shaft where it passes through any intermediate space not served by the air conditioning system. The flue shall be vented to the outside or to ■ space served by the air conditioning system. Such systems shall conform to the requirements of paragraph 9.20.

Group 1 Refrigerants

9.20 Direct Systems containing more than twenty (20)

pounds of a Group 1 refrigerant when used for air conditioning for human comfort, shall be limited by the volume of the space to be air conditioned as follows:

Refrigerant		Maximum quantity in lbs. per 1000 cu. ft. of air conditioned space*
Name	Chemical Formula	
Carbon dioxide	CO_2	12
Dichlorodifluoromethane (Freon-12)	CCl_2F_2	30
Dichloromethane (Carrene No. 1)	CH_2Cl_2	■
Dichloromonofluoromethane (Freon-21)	$CHCl_2F$	13
Dichlorotetrafluoroethane (Freon-114)	$C_2Cl_2F_4$	40
Trichloromonofluoromethane (Freon-11)	CCl_3F	35

* NOTES
a. When the refrigerant containing parts of ■ system are located in one or ■■■ enclosed spaces, the cubical contents of the smallest enclosed space other than the machinery room, shall be used to determine the permissible quantity of refrigerant in the system.
b. Wh■■ the evaporator is located in a duct system, the cubical content of the smallest enclosed space served by the duct system shall be used to determine the permissible quantity of refrigerant in the system unless the air flow to any room served by the duct system cannot be reduced below ¼ of its maximum, in which ■■■ the cubical contents of the entire space served by the duct system shall be used to determine the permissible quantity of refrigerant in the system.

9.21 A system containing more than fifty (50) pounds of a Group 1 refrigerant, other than carbon dioxide, and which includes air ducts shall be of the Indirect type unless it conforms to requirements as follows:

(a) Positive automatic fire damper or dampers shall be provided to cut off the refrigerant containing apparatus from the duct system.

(b) Automatic means shall be provided to close the dampers and to stop the fan when the temperature of the air in the duct at the damper location reaches 210 F. when the damper is on the discharge side of a system containing ■ heating coil and at 125 F. when the damper is on the suction side of the system or on the discharge side of ■ system containing no heating coil.

9.22 A system containing more than one thousand (1000) pounds of a Group 1 refrigerant shall be of the Indirect type with all the refrigerant containing parts, excepting parts mounted outside the building, installed in a machinery room used for no other purpose and in which for Group 1 refrigerants, excepting carbon dioxide, no flame is present or apparatus to produce a flame is installed.

Group 2 Refrigerants

9.30 A system containing more than twenty (20) pounds of a Group 2 refrigerant shall not be used for air conditioning for human comfort unless it is of the Indirect Vented Closed Surface, Double Indirect Vented Open Spray, Indirect Absorptive Brine, or primary circuit of ■ Double Refrigerant type with all the refrigerant containing parts, excepting parts mounted outside the building, installed in ■ machinery room used for no other purpose.

9.31 Any system containing more than six hundred (600) pounds of a Group 2 refrigerant shall have all refrigerant containing parts installed in ■ Class T machinery room.

Group 3 Refrigerants

9.40 Group 3 refrigerants shall not be used except in a Unit System containing not more than six (6) pounds of refrigerant.

SECTION X

INDUSTRIAL OCCUPANCIES

10.10 There shall be no restriction on the quantity or kind of refrigerant used in an Industrial occupancy, except as specified in paragraph 10.20.

10.20 When the number of employees above the first floor exceeds one per one hundred (100) square feet of floor area, the requirements of Commercial occupancies shall apply unless that portion of the building containing more than one employee per one hundred (100) square feet of floor area above the first floor, together with its entrances and exits, be cut off from the rest of the building by vapor-tight construction with self-closing, tight-fitting doors.

SECTION XI

INSTALLATION REQUIREMENTS

Condensing Units

11.10 Not more than two (2) condensing units shall be located one above the other within the same floor area between floor and ceiling.

11.11 All moving machinery shall be provided with adequate guards in accordance with the American Standard Safety Code for Mechanical Power Transmission Apparatus, B15-1927.

11.12 Adequate illumination and clear space for inspection and servicing of condensing units shall be provided.

11.13 Condensing units with enclosures shall be readily accessible for servicing and inspection.

Water Connections

11.20 No connection shall be made with the public water supply which is inconsistent with the regulations of the public authority having jurisdiction. Water used for removing heat from a Refrigerating System shall not be discharged into any water supply where the water is used for drinking purposes.

11.21 Discharge water lines from condensers or other equipment shall not be directly connected to the waste or sewer system in such a manner as to permit siphoning of the waste water into the water supply lines. The waste or discharge from such equipment shall be over and above the rim of a properly trapped and vented plumbing fixture.

Electrical Wiring

11.30 The installation of all electrical equipment and wiring shall be in accordance with the requirements of the latest edition of the National Electrical Code, as approved by American Standards Association.

Gas Devices

11.40 The installation of all gas fuel devices and equipment used with Refrigerating Systems shall be in accordance with the latest edition of National Board of Fire Underwriters' Pamphlet No. 54 entitled "Recommended Good Practice Requirements for Installation, Maintenance and Use of Piping and Fittings for City Gas," as approved by American Standards Association.

Open Flames

11.50 When the quantity of refrigerant in any one Refrigerating System exceeds the amount given in the following table for each one thousand (1000) cubic feet of room volume in which the system or any part thereof is installed, then no flame producing device or hot surfaces above 800 F. shall be permitted in such room and all electrical equipment in the room shall conform to the requirements of Article 500—Hazardous Locations Class I of the latest edition of the National Electrical Code approved by American Standards Association.

Refrigerant		Maximum quantity in lbs. per 1000 cu. ft. of room volume
Name	Chemical Formula	
Butane	C_4H_{10}	3
Ethane	C_2H_6	3
Ethyl chloride	C_2H_5Cl	6
Isobutane	$(CH_3)_3CH$	3
Methyl chloride	CH_3Cl	10
Methyl formate	$HCOOCH_3$	7
Propane	C_3H_8	3

Machinery Room

11.60 Each refrigerating machinery room shall be provided with tight-fitting door or doors and have no partitions or openings that will permit the passage of the refrigerant to other parts of the building.

TABLE 1. DUCT AREAS AND OPENINGS

Weight of refrigerant in system, lbs	Mechanical cu. ft. per minute discharge	Duct area, sq. ft.	Open window or door area, sq. ft.
up to 20	150	1/4	4
50	250	1/3	6
100	400	1/2	10
150	550	2/3	12 1/2
200	680	2/3	14
250	800	1	15
300	900	1	17
400	1,100	1 1/4	20
500	1,275	1 1/4	22
600	1,450	1 1/2	24
700	1,630	1 1/2	26
800	1,800	2	28
900	1,950	2	30
1,000	2,050	2	31
1,250	2,250	2 1/4	33
1,500	2,500	2 1/4	37
1,750	2,700	2 1/4	38
2,000	2,900	2 1/4	40
2,500	3,300	2 1/2	43
3,000	3,700	3	48
4,000	4,600	3 3/4	55
5,000	5,500	4 1/2	62
6,000	6,300	5	68
7,000	7,200	5 1/2	74
8,000	8,000	5 3/4	80
9,000	8,700	6 1/4	85
10,000	9,500	6 1/2	90
12,000	10,900	7	100
14,000	12,200	7 1/2	109
16,000	13,300	7 3/4	118
18,000	14,300	8	125
20,000	15,200	8 1/4	130
25,000	17,000	8 3/4	140
30,000	18,200	9	145
35,000	19,400	9 1/4	150
40,000	20,500	9 1/2	155
45,000	21,500	9 3/4	160

11.61 Each refrigerating machinery room shall be provided with means for ventilation to the outer air. The ventilation shall consist of windows or doors opening to the outer air, of the size shown in Table 1, or of mechanical means capable of removing the air from the room in accordance with Table 1. The amount of ventilation for refrigerant removal purposes shall be determined by the refrigerant content of the largest system in the machinery room.

11.62 When mechanical means are used, they shall consist of ■ power-driven exhaust fan, which shall be capable of removing from the refrigerating machinery room the amount of air specified in Table 1. The inlet to the fan shall be located near the refrigerating equipment. The outlet from the fan shall terminate outside of the building. When air ducts are used on either the inlet or discharge side of the fan, they shall each have an area not less than specified in Table 1.

11.63 Class T machinery rooms in basements or sub-basements shall have adequate mechanical ventilation operating continuously, which may be considered as ■ part of the emergency ventilation required in paragraph 11.61.

Air Duct Systems

11.70 The installation of all Air Duct Systems of air conditioning equipment using mechanical refrigeration for human comfort shall be in accordance with the requirements of the American Standard Regulations for the Installation of Air Conditioning, Warm Air Heating, Air Cooling and Ventilating Systems Z33.2-1938 and all subsequent revisions thereof approved by American Standards Association.

Indirect Open Spray Systems

11.80 Indirect Open Spray Systems containing more than one thousand (1000) pounds of ■ Group 1 refrigerant shall be provided with approved means of preventing the escape of refrigerant into the spray system, except when the vapor pressure of the refrigerant at 32 F. does not exceed atmospheric pressure.

SECTION XII*

REFRIGERANT PIPING, VALVES, FITTINGS AND RELATED PARTS

Materials

12.10 All materials used in the construction and installation of Refrigerating Systems shall be suitable for the refrigerant used, and no material shall be used that will deteriorate due to the chemical action of the refrigerant or the oil, or the combination of both.

Steel and Wrought Iron Pipe

12.11 Standard weight steel or wrought iron pipe may be used for Design Working Pressures not exceeding two hundred fifty (250) pounds per square inch, provided lap welded or seamless pipe is used for sizes larger than two (2) inches (iron pipe size) and extra heavy pipe is used for liquid lines for sizes one and one-half (1½) inches (iron pipe size) and smaller.

12.12 Pipe joints may be screwed, flanged or welded. Screw joints shall conform to American Standards Association Pipe Thread Standard No. B2-1919. Exposed threads shall be tinned or otherwise coated to inhibit corrosion.

12.13 Welds shall conform to the Welding Section of the American Standards Association Code for Pressure Piping B31-1935.

12.14 Valves, flanges and fittings may be made of cast iron, malleable iron, bronze or steel castings, hot forged or drop forged steel, wrought copper, bronze or brass, and shall be of the design and material listed by the manufacturer for the particular refrigerant service.

12.15 Cast iron shall conform to American Society for Testing Materials, designation A-126-30, Class B higher strength gray iron with not less than thirty thousand (30,000) pounds per square inch tensile strength.

*The provisions of this section apply to piping, valves, fittings and related parts for Design Working Pressures not exceeding two hundred fifty (250) pounds per square inch gauge.

12.16 Bushings may be used in fittings when the reduction is two or more pipe sizes. For single pipe size reduction, reducing fittings must be used.

Pipe Bends

12.17 Pipe bends shall be substantially circular in section and free from injurious wrinkles, buckles, kinks and creases. This shall not be construed as barring corrugated pipe bends made of suitable material.

Brass Pipe

12.18 Standard pipe size copper or red brass (not less than eighty (80) per cent copper) may be used.

Copper Tubing

12.20 Copper tubing used for refrigerant piping erected on the premises shall conform to American Society for Testing Materials designation B-88-*33*, grades K or L for dimensions, and shall be absolutely free from scale and dirt.

12.21 Copper tubing of one-eighth (⅛), one-quarter (¼), and five-eighths (⅝) inch nominal sizes in the same standard series as grades K or L of American Society for Testing Materials designation B-88-*33*, shall be considered as meeting the requirements of paragraph 12.20.

Soft Copper Tubing

12.22 Soft annealed copper tubing used for refrigerant piping erected on the premises shall not be used in sizes larger than three-quarters (¾) inch nominal size. It shall conform to grades K or L of American Society for Testing Materials designation B-88-*33*.

12.23 Rigid metal enclosures shall be provided for soft annealed copper tubing used for refrigerant piping erected on the premises, except that flexible metal enclosures may be used at bends or terminals if not exceeding six (6) feet in length. No enclosures shall be required for connections between condensing unit and the nearest riser box, provided such connections do not exceed six (6) feet in length.

12.24 Threaded joints on copper or brass pipe of standard pipe size shall be made with extra heavy brass fittings which conform to Federal Specifications WW-P-461 composition B, Feb. 2, 1932.

12.25 Joints on annealed copper tubing not exceeding three-quarters (¾) inch in outside diameter may be made with flared compression fittings of approved type, provided that all such fittings shall be exposed for visual inspection.

12.26 Joints on hard drawn copper tubing, if of the sweated capillary type, may be made with an alloy having a melting point greater than 1000 F. or with a solder melting at a point below 500 F., but above 350 F.

12.27 Fittings used in sweated capillary joints shall be cast red brass or die pressed brass or copper, or wrought brass or copper, or extruded brass or copper.

12.28 Soldered joints in pipe or tubing erected on the premises shall remain mechanically intact when subjected to a pull-apart test equivalent to a pressure of not less than three hundred (300) pounds per square inch gauge pressure with a temperature of not less than 800 F., except that this requirement shall not apply to soldered joints in pipe or tubing of one-half (½) inch nominal size or smaller when used in systems containing not more than twenty (20) pounds of refrigerant.

12.29 Any evaporator located in an air duct of an air conditioning system for human comfort shall be constructed to withstand without leakage a temperature of 1000 F.

Stop Valves

12.30 Stop valves shall be installed on all systems containing more than twenty (20) pounds but less than one hundred (100) pounds of refrigerant at locations as follows:
(a) Each inlet and each outlet pipe of each compressor.
(b) Each outlet of each liquid receiver.

12.31 Stop valves shall be installed on all systems containing one hundred (100) pounds or more of refrigerant at locations as follows:

(a) Each inlet and each outlet pipe of each compressor.
(b) Each inlet and each outlet pipe of each liquid receiver.
(c) Each liquid and each suction branch header.

12.32 Stop valves used with soft annealed copper tubing or hard drawn copper tubing three-quarter (¾) inch nominal size or smaller shall be securely mounted independent of tubing fastenings or supports.

12.33 Stop valves placed where it is not obvious what they control shall be suitably labelled. Numbers may be used to label the valves provided a key to the numbers is located near the valves.

Pipe and Tube Supports

12.40 All refrigerant piping shall be securely supported by means of metal hangers, brackets, straps, clamps or pedestals, in such manner as to relieve joints of harmful strains and vibration. The supports shall be used for no other purpose. Hangers for refrigerant piping above seven-eighths (⅞) inch outside diameter, shall not be less than 0.125 square inch cross section.

Location of Refrigerant Piping

12.50 Refrigerant piping crossing an open space which affords passageway in any building shall not be less than seven and one-half (7½) feet above the floor unless against the ceiling of such space.

12.51 Refrigerant piping shall not be placed in public hallways, lobbies, stairways, elevators or dumbwaiter shafts, excepting that such refrigerant piping may pass across a public hallway if there be no joints in the section in the public hallway, and provided non-ferrous tubing of one (1) inch nominal outside diameter and less be contained in a rigid metal pipe.

12.52 Refrigerant piping, with or without insulation covering, shall be exposed to view, excepting for mechanical protection herein specified, or when located in the cabinet of a Unit System. This does not apply to refrigerant piping installed outside the building or in a flue vented to the outer air.

SECTION XIII

DESIGN, CONSTRUCTION, AND SAFETY DEVICES

Design and Construction

13.10 Every part of a Refrigerating System, except pressure gauges and control mechanisms, shall be designed, constructed, and assembled to withstand the test pressures specified in Table 3, without being stressed beyond one-third (1/3) of its ultimate strength.

13.11 Equipment listed by ■ recognized engineering testing laboratory having ■ follow-up inspection service, shall be considered as conforming with the requirements of paragraph 13.10.

13.12 Refrigerant containing vessels which are not a part of equipment listed by a recognized engineering testing laboratory having ■ follow-up inspection service, shall be constructed in accordance with the rules of Section VIII (Unfired Pressure Vessel Section) of the 1937 A.S.M.E. Boiler Construction Code, except that compliance with paragraphs U-2 to U-10 inclusive and U-65 and U-66 of the aforesaid A.S.M.E. Code shall not be required.

13.20 Every system, except as provided in paragraphs 13.21, 13.22 and 13.23, shall be protected by ■ pressure relief device unless so constructed that pressure due to fire conditions will be relieved safely by soldered joints, lead gaskets, fusible plugs, or other parts of the system.

Pressure Relief Devices

*13.21** Each pressure vessel containing liquid refrigerant and which may be shut off by valves from all other parts of a refrigerating system, shall be protected by an approved pressure relief valve in parallel with a rupture member or a second approved

* It may be necessary on large pressure vessels containing liquid refrigerant to use two or more pressure relief devices in parallel to obtain the required minimum rated capacity. In such cases the battery of pressure relief devices shall be considered as ■ unit and therefore ■ one pressure relief device.

pressure relief valve if its gross volume exceeds five (5) cubic feet unless its diameter does not exceed six (6) inches.

13.22 Each pressure vessel having ■ gross volume of five (5) cubic feet or less, containing liquid refrigerant and which may be shut off by valves from all other parts of ■ refrigerating system, shall be protected by an approved pressure relief device or an approved fusible plug.

13.23 The requirements of 13.21 and 13.22 shall not apply to flooded evaporators located in a refrigerator cabinet.

13.24 Each pressure vessel shall have the Design Working Pressure stamped thereon if its gross volume exceeds five (5) cubic feet.

13.25 Compressors operating above fifteen (15) pounds per square inch gauge and having ■ displacement exceeding one hundred (100) cubic feet per minute, shall be equipped by the manufacturer with a pressure relief device of adequate size to prevent rupture of the compressor, located between the compressor and stop valve on the discharge side. The discharge from such relief device may be vented to the atmosphere or into the low pressure side of the system.

Capacity Rating

13.30 The rated discharge capacity of ■ pressure relief valve, expressed in pounds of air per minute, shall be one-fifth (1/5) of its discharge capacity determined by test with the outlet open to the atmosphere and with a differential pressure across the restraining member equal to twice the marked pressure setting of the pressure relief valve.

13.32 The rated discharge capacity of rupture members and discharge piping shall be ■ given in Table 2.

Required Capacity

13.33 The minimum required rated discharge capacity of the pressure relief device for ■ refrigerant containing vessel shall be determined by the following formula:

$$C = fDL.$$

Where C = Minimum required rated discharge capacity of the relief device in pounds of air per minute.
D = Outside diameter of the vessel in feet.
L = Length of the vessel in feet.
f = Factor dependent upon kind of refrigerant as follows:

Kind of Refrigerant	Value of "f"
Ammonia ..... NH_3	0.1
Dichlorodifluoromethane Freon-12	0.3
All other refrigerants	0.2

Pressure Setting

13.34 All pressure relief devices for refrigerant containing vessels shall be directly pressure actuated.

13.35 All pressure relief valves for refrigerant containing vessels shall be set to function at a pressure not to exceed 25% above the Design Working Pressure of the vessel.

13.36 All rupture members used in parallel with pressure relief valves on refrigerant containing vessels shall be set to function at a pressure not to exceed ninety (90) per cent above the Design Working Pressure of the vessel.

Pressure Setting Test

13.37 The pressure setting of relief devices for refrigerant containing vessels shall be tested with the outlet open to the atmosphere and the relief device shall function at a pressure not more than ten (10) per cent above the pressure marked thereon, if such marking is one hundred (100) pounds per square inch or more, or at not more than ten (10) pounds per square inch above the pressure marked thereon, if such marking is less than one hundred (100) pounds per square inch.

*Marking** (See footnote page 654L)

13.38 All pressure relief valves for refrigerant containing vessels shall be set and sealed by the manufacturer. The name or trade-mark of the manufacturer, the pressure setting expressed in pounds per square inch gauge, the rated discharge

TABLE 2

DISCHARGE CAPACITY OF RUPTURE MEMBERS AND DISCHARGE PIPING IN POUNDS OF AIR PER MINUTE

Maximum relief pressure lbs. per sq. in. gauge	Design Working Pressure lbs. per sq. in. gauge	Pipe length, ft.	Standard Weight Pipe, Nominal Size, inches — Discharge capacity in pounds of air per min.							
			½	¾	1	1¼	1½	2	2½	3
100	53	50	2.6	5.2	9.6	19.0	28	52	81	140
"	"	75	2.2	4.2	7.8	16.0	23	43	66	114
"	"	100	1.8	3.6	6.8	13.0	20	37	57	99
"	"	150	1.6	3.0	5.4	11.0	16	30	47	81
"	"	200	1.4	2.6	4.8	9.6	14	26	41	70
"	"	300	1.0	2.2	4.0	7.8	11	21	33	57
125	66	50	3.2	6.4	12.0	24.0	35	65	101	175
"	"	75	2.6	5.2	9.8	19.0	28	53	82	143
"	"	100	2.2	4.6	8.4	17.0	25	46	72	124
"	"	150	1.8	3.8	7.0	14.0	20	38	58	101
"	"	200	1.6	3.2	6.0	12.0	17	33	51	87
"	"	300	1.4	2.6	4.8	9.8	14	27	42	72
150	79	50	3.8	7.8	14.0	28	42	78	122	210
"	"	75	3.2	6.4	12.0	23	34	64	99	171
"	"	100	2.8	5.4	10 0	20	30	55	86	148
"	"	150	2.2	4.4	8.2	16	24	45	70	121
"	"	200	2.0	3.8	7.0	14	21	39	61	105
"	"	300	1.6	3.2	5.8	12	17	32	50	86
175	92	50	4.6	9.0	17.0	33	49	91	142	244
"	"	75	3.8	7.4	14.0	27	40	75	116	200
"	"	100	3.2	6.4	12.0	23	34	64	100	173
"	"	150	2.6	5.2	9.6	19	28	53	82	141
"	"	200	2.2	4.6	8.4	17	24	46	71	122
"	"	300	1.8	3 6	6 8	14	20	37	58	100
200	105	50	5.2	10.0	19.0	38	56	104	162	280
"	"	75	4.2	8.4	16.0	31	45	85	132	228
"	"	100	3.6	7.2	14.0	27	39	74	115	198
"	"	150	3.0	6.0	11.0	22	32	60	94	162
"	"	200	2.6	5.2	9.6	19	28	52	81	140
"	"	300	2.2	4.2	7.8	16	23	43	66	114
250	131	50	6.4	13.0	24.0	47	70	130	206	350
"	"	75	5.4	11.0	20.0	39	57	106	166	286
"	"	100	4.6	9.2	17.0	34	49	92	144	248
"	"	150	3.8	7.4	14.0	27	40	75	117	202
"	"	200	3.2	6.4	12.0	24	35	65	102	175
"	"	300	2.6	5.2	9.8	19	28	53	83	143

TABLE 2 (*Continued*)

DISCHARGE CAPACITY OF RUPTURE MEMBERS AND DISCHARGE PIPING IN POUNDS OF AIR PER MINUTE

Maximum relief pressure lbs. per sq. in. gauge	Design Working Pressure lbs. per sq. in. gauge	Pipe length, ft.	Standard Weight Pipe, Nominal Size, inches							
			Discharge capacity in pounds of air per min.							
			½	¾	1	1¼	1½	2	2½	3
300	158	50	7.8	15.0	29	57	83	156	244	420
"	"	75	6.4	13.0	23	46	68	128	199	342
"	"	100	5.4	11.0	20	40	59	111	172	296
"	"	150	4.6	9.0	17	33	48	90	140	242
"	"	200	4.0	7.8	14	28	42	78	122	210
"	"	300	3.2	6.4	12	23	34	64	100	171
400	210	50	10.0	21.0	38	76	111	208	324	560
"	"	75	8.4	17.0	31	62	91	170	264	457
"	"	100	7.4	15.0	27	54	79	148	230	396
"	"	150	6.0	12.0	"	44	64	120	187	324
"	"	200	5.2	10.0	19	38	56	104	163	280
"	"	300	4.2	8.4	16	31	45	85	133	228
500	263	50	13.0	26	48	94	139	260	406	700
"	"	75	11.0	21	39	77	114	213	330	570
"	"	100	9.2	18	34	67	98	184	287	495
"	"	150	7.4	15	28	55	80	150	234	405
"	"	200	6.4	13	24	47	70	130	203	350
"	"	300	5.2	10	19	39	57	106	166	286

capacity expressed in pounds of air per minute, and the maximum equivalent length of discharge piping that can be attached to the pressure relief valve without loss of discharge capacity, shall be cast or stamped on the device, or on a metal plate permanently attached thereto.

13.39 Each rupture member for refrigerant containing pressure vessels shall have cast or stamped on the device or on a

*The maximum length of discharge line which can be attached to a pressure relief valve without loss of discharge capacity may be determined from Table 2, using that length of line for the size of the discharge connection of the pressure relief valve which has twice the rated discharge capacity of the pressure relief valve at a Design Working Pressure equal to the pressure setting of the pressure relief valve.

metal plate permanently attached thereto the name or trade mark of the manufacturer and the bursting pressure of the rupture member expressed in pounds per square inch gauge.

Installation Requirements

13.40 A rupture member may be located between a pressure relief valve and a pressure vessel.

13.41 No stop valve shall be located between any automatic pressure relief device and the part or parts of the system protected thereby, except when the parallel relief devices mentioned in Par. 13.21 are so arranged that only one can be rendered inoperative at a time for testing or repair purposes.

13.42 All pressure relief devices shall be connected as nearly as practicable directly to the pressure vessel or other parts of the system protected thereby, and shall be placed above the liquid refrigerant level.

13.43 The seats and discs of pressure relief devices for refrigerant containing vessels shall be constructed of suitable material to resist refrigerant corrosion.

Discharge from Pressure Relief Devices

13.44 Pressure relief devices and fusible plugs on all systems containing more than thirty (30) pounds of refrigerant, except those used to protect compressors, shall discharge to the outside of the building in an approved manner.

13.45 The size of the discharge opening and pipe from the pressure relief device shall not be less than the size of the relief device inlet. The discharge from more than one relief device may be run into a common header, the area of which shall be not less than the sum of the areas of the pipes connected thereto.

Ammonia Discharge

13.46 Where ammonia is used, the discharge may be into a tank of water which shall be used for no purpose except ammonia absorption. At least one (1) gallon of fresh water shall be provided for every one (1) pound of ammonia in the system.

The water used shall be prevented from freezing without the use of salt or chemicals. The tank shall be substantially constructed of not less than one-eighth (⅛) inch or No. 11 U. S. gauge iron or steel. No horizontal dimension of the tank shall be greater than one-half (½) the height. The tank shall have a hinged cover, or, if of the enclosed type, shall have a vent hole at the top. All pipe connections shall be through the top of the tank only. The discharge pipe from the pressure relief valves shall discharge the ammonia in the center of the tank near the bottom.

Sulphur Dioxide Discharge

13.47 Where sulphur dioxide is used, the discharge may be into a tank of absorptive brine which shall be used for no purpose except sulphur dioxide absorption. There shall be one (1) gallon of standard dichromate brine (two and one-half (2½) pounds sodium dichromate per gallon of water) for each pound of sulphur dioxide in the system. Brines made with caustic soda or soda ash may be used in place of sodium dichromate provided the quantity and strength give the equivalent sulphur dioxide absorbing power. The tank shall be substantially constructed of not less than one-eighth (⅛) inch or No. 11 U. S. gauge iron or steel. The tank shall have a hinged cover, or, if of the enclosed type, shall have a vent hole at the top. All pipe connections shall be through the top of the tank only. The discharge pipe from the pressure relief valve shall discharge the sulphur dioxide in the center of the tank near the bottom.

Pressure Limiting Devices

13.50 Pressure limiting devices are required on all systems containing more than twenty (20) pounds of refrigerant and operating above atmospheric pressure, and on all Water Cooled Systems so constructed that the compressor or generator is capable of producing a pressure in excess of the test pressure.

13.51 Pressure limiting devices shall stop the action of the compressor at a pressure less than ninety (90) per cent of the

pressure relief device setting but not more than ninety (90) per cent of the test pressures given in Table 3.

13.52 Pressure limiting devices shall be connected between the compressor and the stop valve on the discharge side.

Test of Refrigerant Containing Vessels

13.60 Refrigerant containing vessels, the shells of which have been previously tested under hydrostatic pressure of not less than one and one-half times the Design Working Pressure may be finally tested with pneumatic pressure at one and one-half times the Design Working Pressure, instead of hydrostatic pressure.

Gauges

13.70 Liquid level gauge glasses, except those of the bull's-eye type, shall have automatic closing shut-off valves, and such glasses shall be adequately protected against injury.

Motor Protection

13.80 Motors of Refrigerating Systems shall be adequately protected against hazardous overheating under normal or abnormal operating conditions.

SECTION XIV

TESTS

General

14.10 Every refrigerant containing part of every system shall be tested and proved tight by the manufacturer at not less than the minimum test pressures shown in Table 3.

14.11 Every refrigerant containing part of every system that is erected on the premises, except compressors, safety devices, pressure gauges, and control mechanisms, that are factory tested, shall be tested and proved tight after complete installation and before operation at not less than the minimum pressures shown in Table 3.

Test Medium

14.12 No oxygen or any combustible gas or combustible mixture of gases shall be used for testing.

Test Pressures

14.13

TABLE 3.

Refrigerant		Min. test pressure, lbs. per sq. in.	
Name	Chemical Formula	High pressure side	Low pressure side
Ammonia	NH_3	300	150
Butane	C_4H_1	90	50
Carbon dioxide	CO_2	1500	1000
Dichlorodifluoromethane (Freon-12)	CCl_2F_2	235	145
Dichlorotetrafluoroethane (Freon-114)	$C_2Cl_2F_4$	80	50
Dichloromethane (Carrene No. 1) (Methylene chloride)	CH_2Cl_2	30	30
Dichloromonofluoromethane (Freon-21)	$CHCl_2F$	70	50
Dichloroethylene	$C_2H_2Cl_2$	30	30
Ethane	C_2H_6	1100	600
Ethyl chloride	C_2H_5Cl	60	50
Isobutane	$(CH_3)_3CH$	130	75
Methyl chloride	CH_3Cl	215	125
Methyl formate	$HCOOCH_3$	50	50
Propane	C_3H_8	325	210
Sulphur dioxide	SO_2	170	95
Trichloromonofluoromethane (Freon-11)	CCl_3F	50	30

Refrigerants Not Listed

14.14 For refrigerants not listed in Table 3, the test pressure for the high pressure side shall be not less than the saturated vapor pressure of the refrigerant at 150 F. The test pressure for the low pressure side shall be not less than the saturated vapor pressure of the refrigerant at 115 F. In no case shall the test pressure be less than thirty (30) pounds per square inch by gauge.

Posting of Tests

14.15 A dated declaration of tests, signed by the installer, shall be mounted in a frame, protected by glass, and posted in the machinery room. If an inspector is present at the tests he shall also sign the declaration.

SECTION XV

INSTRUCTIONS

User's Responsibility

15.10 All Refrigerating Systems shall be maintained in a cleanly manner, free from accumulations of oily dirt, waste, and other debris, and shall be kept readily accessible at all times.

Instructions

15.20 It shall be the duty of the person in charge of the premises on which a Refrigerating System containing more than twenty (20) pounds of refrigerant is installed, to place a card conspicuously ▬ near as practicable to the refrigerant condensing unit giving directions for the operation of the system, including precautions to be observed in case of ▪ breakdown or leak as follows:

(a) Instructions for shutting down the system in case of emergency.

(b) The name, address and day and night telephone numbers for obtaining service.

(c) The name, address and telephone number of the municipal inspection department having jurisdiction and instructions to notify said department immediately in case of emergency.

Signs

15.30 Each Refrigerating System shall be provided with an easily legible metal sign permanently attached and easily accessible, indicating thereon the name and address of the manufacturer or installer, the kind and total number of pounds of refrigerant contained in the system, and the field test pressure applied.

15.31 Systems containing more than one hundred (100) pounds of refrigerant should be provided with metal signs having letters of not less than one-half (½) inch in height designating the main shut-off valves to each vessel, main steam or electrical control, remote control switch, and pressure limiting device. On all exposed high pressure and low pressure piping in each room

where installed outside the machinery room, shall be signs as above with the name of the refrigerant and the letters HP or LP.

Marking

15.32 Each separately sold refrigerant containing vessel larger than five (5) cubic feet in gross volume, each refrigerant condensing unit, and each refrigerant compressor shall carry a nameplate marked with the manufacturer's name and address, identification number, and name of refrigerant used.

Helmets

15.40 One mask or helmet shall be required where amount of Group 2 refrigerants between one hundred (100) and one thousand (1000) pounds, inclusive, are employed. If more than one thousand (1000) pounds of Group 2 refrigerants are employed, at least two masks or helmets shall be required.

15.41 Only complete helmets or masks marked as approved by the Bureau of Mines of the United States Department of the Interior and suitable for the refrigerant employed shall be used and they shall be kept in a suitable cabinet immediately outside the machinery room or other approved accessible location.

15.42 Canisters or cartridges of helmets or masks shall be renewed immediately after having been used or the seal broken and if unused, must be renewed at least once every two (2) years. The date of filling shall be marked thereon.

Refrigerant Storage

15.50 Not more than three hundred (300) pounds of refrigerant in approved containers shall be stored in a machinery room.

15.51 No refrigerant shall be stored in a room in which less than twenty (20) pounds are used in the system.

15.52 Refrigerants on the user's premises in excess of that permitted in the machinery room shall be stored in a fireproof shed or room used for no other purpose.

Charging and Discharging Refrigerants

15.60 When refrigerant is added to a system, except a Unit System containing not more than six (6) pounds of refrigerant, it shall be charged into the low pressure side of the system. No container shall be left connected to a system except while charging or withdrawing refrigerant.

15.61 Refrigerants withdrawn from Refrigerating Systems shall only be transferred to approved containers. No refrigerant shall be discharged to a sewer.

15.62 The containers from which refrigerants are discharged into or withdrawn from a Refrigerating System must be carefully weighed each time they are used for this purpose, and the containers must not be filled in excess of the permissible filling weight for such containers and such refrigerants as are prescribed in the Interstate Commerce Commission's "Regulations for the Transportation by Rail of Explosives and other Dangerous Articles in Freight, Express and Baggage Services including Specifications for Shipping Containers," effective October 1, 1930, with supplements 1 to 18 inclusive.

453A. COMPOSITE WALL K FORMULA:

$$K = \frac{1}{\frac{1}{K_1} + \frac{1}{K_2} + \frac{1}{K_3}} \left(\begin{matrix} \text{not considering} \\ \text{air film} \end{matrix} \right)$$

If air film is considered then:

$$U = \frac{1}{\frac{1}{1.25} + \frac{t_1}{K_1} + \frac{t_2}{K_2} + \frac{t_3}{K_3} + \frac{1}{1.25}}$$

An air film that clings to the outer and inner surfaces of the cabinet adds to the insulating value of the walls of the cabinet. This added resistance is calculated as in the above formula ($K = 1.25$). The symbols t_1, t_2, and t_3 represent the thickness in inches of the insulation concerned.

CHAPTER XVIII

AIR-CONDITIONING

People are continually endeavoring to improve their surroundings in order to increase the comfort of living. Among the more recent improvements we must consider air-conditioning as very important, for it deals with means of making the atmosphere in which we live and work more healthful and comfortable. The important factors involved in a complete air conditioning installation include:

1. Temperature control
2. Humidity control
3. Air movement and circulation
4. Air filtering, cleaning and purification

Complete air-conditioning provides automatic control of the above factors for all outdoor weather conditions for both summer and winter. Recently, cooling means have been developed for summer use in making residences, factories, railway coaches, theaters, office buildings, hospitals, and other structures more comfortable in the summer time.

In addition to the comfort phases of air-conditioning, certain industries have found that air-conditioning of their plants makes possible more complete control of manufacturing processes and therefore controls their finished product. Such industries include: printing, textile making, particularly artificial silk manufacturing, milling and baking, furniture, drug manufacturing, and many others.

The first step in the direction of air-conditioning was in the development of the central heating plant. The second step was the development of automatic controls for regulating the heating plant. The final step was the development of automatic refrigeration devices which could be employed for summer cooling and dehumidifying the air.

454. TEMPERATURE, HUMIDITY, AND COMFORT:

Temperature of air affects our comfort; however, there is no best temperature for comfort. Comfortable temperatures are influenced by the humidity and by air movement.

The normal temperature of the human body is 98.6°F., and since in the temperate zones the average atmospheric temperatures are below the body temperature, clothing is worn to conserve the body heat.

As heat is continually being generated in the body, heavy clothing in the winter time insulates the body to retain the heat so that we may be warm.

In the summer time while the atmosphere is warm, it is often difficult for the body to radiate sufficient heat when it is generated, particularly if the humidity is high and evaporation is retarded.

Humidity is a term used to describe the presence of moisture or water vapor in the air. The amount of moisture that the air will hold depends upon the temperature of the air. Warm air will hold more moisture than cold air. The amount of humidity in the air affects the rate of evaporation of perspiration from our bodies. Dry air causes rapid evaporation which cools the surface of our bodies and makes us feel cool. Moist (humid) air does not cause rapid evaporation of perspiration; thus we feel warm and depressed although the temperature as indicated by a thermometer may be the same in each case.

455. RELATIVE HUMIDITY:

Relative humidity is a term used to express the amount of moisture in a given sample of air in comparison with the amount of moisture the air would hold if saturated at the temperature at which the sample was taken. Relative humidity is expressed in percentage as 30 per cent, 75 per cent, 85 per cent, etc.

Referring to Figure 320, Point B contains 111 grains of moisture per pound of dry air. The saturated condition (Point C) for the corresponding temperature (85°F.) will hold 183 grains of moisture per pound of air. The relative humidity for Point B $= \frac{111}{185} = 60$ per cent. Line A to B

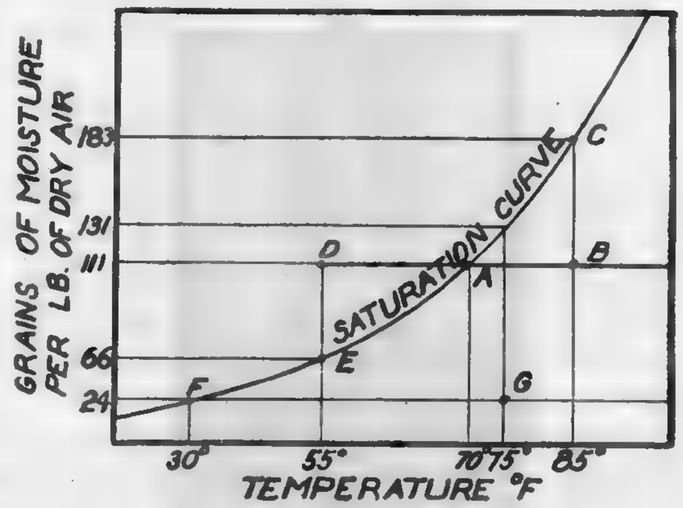


Fig. 320. Illustration of a typical water vapor saturation curve for air. Note that as the temperature increases the amount of moisture that the air will hold also increases

represents what happens when saturated air is warmed. Point D represents what happens when saturated air is cooled. The moisture represented by the distance D to E is condensed out of the air, since air at the temperature corresponding to Point D (55°F.) will hold only 66 grains of moisture. The amount condensed is 111—66 = 45 grains.

A typical winter condition is represented by Point F. Saturated air is taken indoors at 30°F. and 100 per cent relative humidity. It holds 24 grains of moisture. If this

air is heated to 75°F. and no moisture added, its new condition will be represented by Point G. The saturated condition for Point G would be 131 grains. Since the air has only 24 grains, the relative humidity is $\frac{24}{131} = 18.3$ per cent. This is too dry for comfort, as evaporation will take place rapidly from the body and nasal passages and one is likely to feel cold. Actual winter conditions in homes are often much worse than this and relative humidities of 8 per cent to 10 per cent are common too often for health.

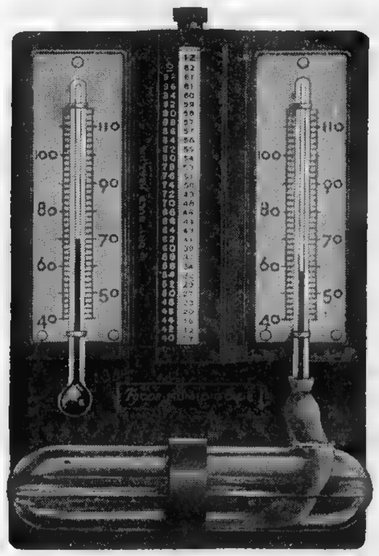


Fig. 321. A typical wet and dry bulb thermometer
(Courtesy of: Taylor Instrument Company)

Air movement is also an important factor affecting comfort. If cool dry air is circulated past a warm body, rapid radiation from the body will be increased, which tends to cool the body. In the winter time when a considerable difference in temperature exists indoors and outdoors, if there is no air movement within a room, the air may tend to stratify, that is, the cold air will sink to the floor and the warmer air

rise to the ceiling. By providing a certain amount of air movement in such a room the air will be stirred up so that a more or less uniform temperature will exist throughout the room. Air movement is usually accomplished by means of fans located in air-conditioners or in air ducts.

456. HUMIDITY MEASUREMENT:

Relative humidity is measured by an instrument called the hygrometer. The simplest form of hygrometer consists of a wet and dry bulb thermometer. The wet bulb thermometer is merely an ordinary thermometer having a wick enclosing the thermometer bulb and extending into a small water reservoir. Figure 321. As the wick soaks up water from the reservoir, it moistens the bulb of the thermometer and evaporation of this moisture takes place. The evaporation (latent heat of evaporation, Paragraph 19) removes heat from the thermometer bulb and cools it. This bulb is called the wet bulb. The wet bulb temperature, except in cases of 100 per cent relative humidity, will be lower for a given set of conditions than will the dry bulb temperature. It is evident that under conditions of very low humidity evaporation takes place rapidly from the surface of the wet bulb. This will result in a much lower wet bulb temperature, while under conditions of 100 per cent humidity no more moisture can be absorbed by the air and the two thermometers, wet and dry bulb, will read the same. Tables and charts have been worked out using these two temperatures in order to arrive at the relative humidity for the conditions measured. Charts which show the relation between wet bulb temperature, dry bulb temperature, and relative humidity are called "psychrometric" charts. Other instruments may be used for measuring relative humidity other than the wet and dry bulb thermometers. Such substances as dry wood, human hair, and certain

vegetable fibers have a great tendency to change their size or shape depending upon their moisture content. Figure 322. If these substances are arranged in such a manner that air can circulate past them freely, they will absorb moisture from the air depending upon the humidity of the air and therefore respond to the atmospheric humidity. By connecting these substances to certain mechanisms, and by calibrating the mechanism, we are able to develop accurate hygrometers. Figure 323 illustrates a typical psychrometric chart. The

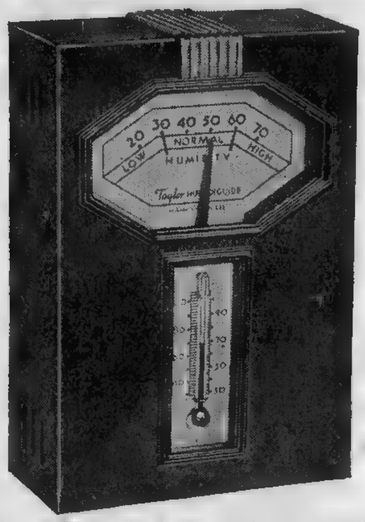


Fig. 322. Dial type hygrometer
(Courtesy of: Taylor Instrument Company)

values along the horizontal lines represent dry bulb temperatures in °F. The values along the vertical lines represent grains of moisture per pound of dry air. The 100 per cent humidity line or the line of saturation is indicated by A. The wet bulb temperatures are also indicated on curve A. This psychrometric chart may be used in connection with the wet and dry bulb thermometers to determine the relative humidity under any conditions. Example: Given the dry bulb temperatures of 75°F. If the wet bulb temperature is

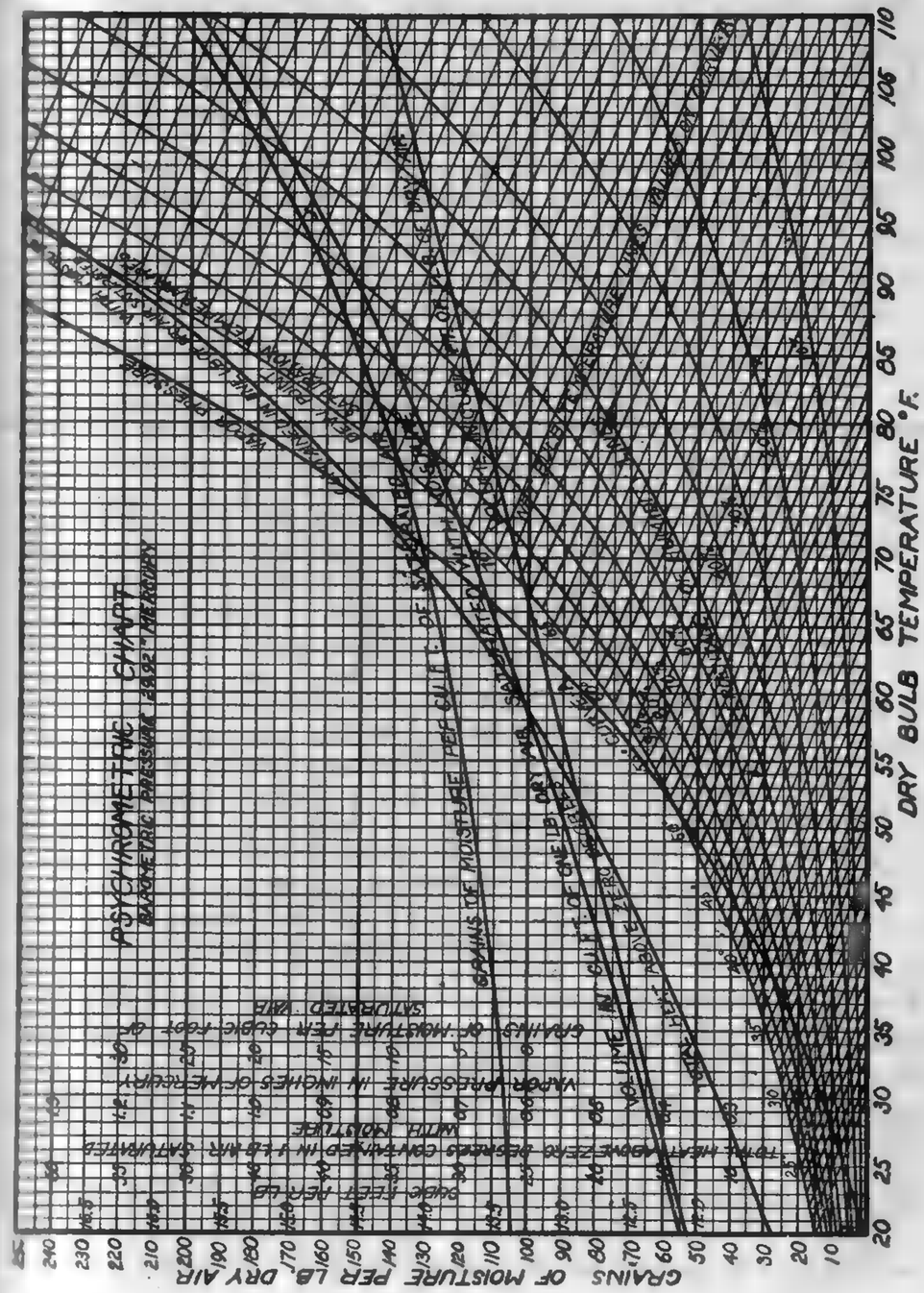

DRY BULB TEMPERATURE °F.
GRAINS OF MOISTURE PER LB. DRY AIR
PSYCHROMETRIC
BAROMETRIC PRESSURE
GRAINS OF MOISTURE PER CUBIC FOOT OF
SATURATED AIR
VAPOR PRESSURE IN INCHES OF MERCURY
WITH MOISTURE
TOTAL HEAT ABOVE ZERO REQUIRED TO VAPORIZE ONE LB. OF WATER AT 32° F. AND ADD IT TO AIR SATURATED

Fig. 323. Psychrometric chart
(Courtesy of: Carrier Corporation)

60°F., what is the relative humidity? Refer to the psychrometric chart: the vertical line corresponding to the 75°F. dry bulb temperature crosses the oblique line corresponding to the 60° wet bulb temperature just above the 40 per cent humidity line—approximately 41 per cent.

The "dew" point is also indicated upon the psychrometric chart. This is the temperature below which if a quantity of air is cooled, moisture will start to condense out. It also is

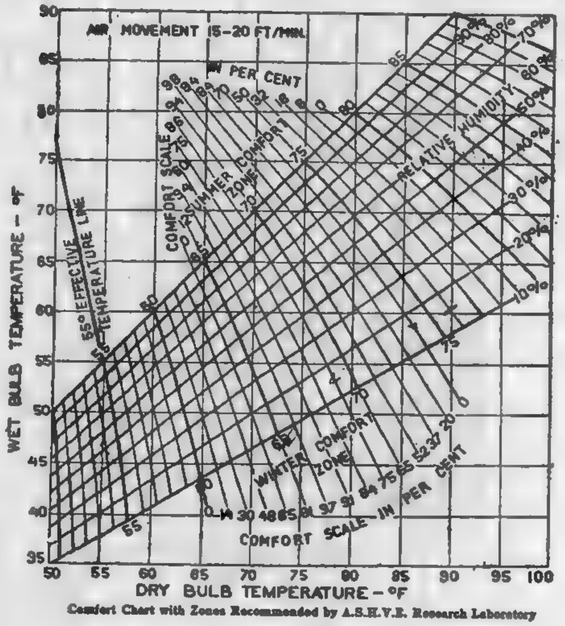

AIR MOVEMENT 15–20 FT/MIN.
IN PER CENT
COMFORT SCALE 95
SUMMER COMFORT ZONE
RELATIVE HUMIDITY
65° EFFECTIVE TEMPERATURE LINE
WINTER COMFORT ZONE
COMFORT SCALE—IN PER CENT
WET BULB TEMPERATURE – °F
DRY BULB TEMPERATURE – °F
50 55 60 65 70 75 80 85 90 95 100
35 40 45 50 55 60 65 70 75 80 85 90 95
Comfort Chart with Zones Recommended by A.S.H.V.E. Research Laboratory

Fig. 324. A graphical representation of a comfort zone
(Courtesy of: The Society of Refrigerating Engineers)

the 100 per cent humidity point. Example: What is the dew point for a sample of air in which the temperature is 80°F. and the relative humidity 60 per cent? Referring to the psychrometric chart, the point where the 80°F. line intersects the 60 per cent humidity line represents the quantity of moisture contained in each pound of air. If this air is cooled without a change in its moisture content, as represented by the horizontal line going through this point, it will

be found that the horizontal line intersects the dew point line at a temperature approximately 64°F., which is the dew point for the sample under discussion.

457. EFFECTIVE TEMPERATURE:

As has been indicated, comfortable conditions result from a combination of temperature, humidity, and air movement. However, one may have equal comfort under varying absolute values of these three factors. For instance, the high relative humidity, which would tend to be oppressive, may be counteracted by a relatively low temperature; rapid air movement, or as is in the case of many homes in the winter time, a low relative humidity is compensated for by an increase in room temperature and a very slight air movement. Figure 324 illustrates what is commonly accepted as the comfort zone for the above conditions. It will be noticed that this comfort zone represents a considerable area. However, experiments have indicated that any point in this area gives approximately equal comfort under equal conditions of clothing and work.

While our studies so far would indicate that we should establish certain comfort zones of effective temperature in our residences and places of work, this is not entirely true due to the fact that we are not able to air-condition all outdoors and that a certain portion of our time must be spent outdoors. The human body is able to accustom itself only to certain changes in a given length of time. It, therefore, becomes necessary to so regulate air-conditioning equipment that it will give a certain degree of air-conditioning. While this will be comfortable in itself, it will not subject the person to too great a shock on entering this conditioned space, or when going out into the normal outdoor atmosphere. It may, therefore, be said that air-conditioning is, to some ex-

tent, a compromise between the actual atmospheric conditions and the ideal conditions as indicated in the comfort zone.

We compensate for some of these changes by clothing. For example, in the winter time we attempt to maintain temperatures of approximately 70°F. to 75°F. indoors, although the temperature outside may be 0°F., which is a temperature difference of 70°F. This is because it is usually considered more comfortable to put on additional clothing when going outdoors under such conditions than to remain indoors with sufficient clothing to be comfortable at a temperature only a few degrees above zero. However, in the summer time, the reverse of this is not true. We do not dress warmer when we enter a space conditioned to 70°F. when the outside temperature is 90° to 100°F. Instead of feeling comfortable on entering such a conditioned space, we may feel chilled and too cold. It is, therefore, important that a compromised condition be maintained which corresponds to some extent with outdoor temperature.

458. AIR-CONDITIONING EQUIPMENT:

Air-conditioning equipment may be divided into six headings. These are:

1. Heating facilities
2. Humidifying equipment
3. Filtering and cleaning equipment
4. Circulating equipment
5. Dehumidifying equipment
6. Cooling equipment

Naturally not all of these devices are in use at the same time. During the summer time we do not use heating or humidifying equipment, but rather use the cooling and the dehumidifying equipment. In the winter time we use the heating and the humidifying equipment. The other parts such as filtering,

cleaning equipment, and circulating equipment are used the year round. Complete air-conditioning equipment may be constructed in three different forms:

1. The entire air conditioning plant may be located in the basement and conditioned air circulated throughout the building.
2. The heating and cooling equipment (refrigeration) may be located in the basement, but pipe lines constructed throughout the building carry the heating and cooling mediums to the various rooms. Small ducts in this case usually provide ample ventilation and air circulation.
3. Unit installations have a complete plant located in each room. Such plants usually contain humidifying and dehumidifying equipment, as well as heating, cooling, and air circulating equipment, although the heat source may be outside the room if the installation uses steam or hot water for its heating medium.

459. AIR-CONDITIONED STRUCTURES:

It has been predicted that air-conditioning will be a tremendous factor in our economic growth with the advent of the increase in home building. However, the air-conditioning of many homes and other structures presents some insulation problems which must be solved in order that the operating cost of the air-conditioning equipment will not be too high. Since air-conditioning implies controlled temperature and humidity, such factors as heat leakage by conduction or convection is an important factor. Air-conditioned structures should be very well insulated in order to eliminate conduction through the walls. All dead air spaces in walls, particularly outside walls, should be thoroughly sealed in order to eliminate convection. Roofs and ceilings particularly should have

heavy insulation on them. For summer air-conditioning in addition to the above, it is often desirable to put on awnings to keep the sun from shining through the windows and increasing the heat load on the cooling plant. If possible, roofs should be painted a light color in order that as little heat may be absorbed as possible. Double windows should be installed if a very great temperature difference is to be maintained. Also all doors and windows should be kept closed in order that very little of the conditioned air will be allowed to escape; however, an adequate and controlled air change is necessary to keep the air-conditioned space healthful.

460. HEATING EQUIPMENT FOR AIR-CONDITIONING:

Heating equipment must be entirely automatic in its operation. The source of the heat such as coal, oil, or gas is not important and the choice will be governed largely by the location and equipment available. In plants in which a central plant is built into the basement and the air circulated throughout the structure, it will be necessary to filter carefully and clean the air as it is circulated. With steam heating plants, radiator or heating coils are usually incorporated in the room air-conditioning units; and the necessary humidifying and filtering are done in each room unit.

461. COOLING EQUIPMENT FOR AIR-CONDITIONING PURPOSES:

The cooling equipment usually consists of refrigeration coils; these coils are maintained at temperatures of 40° to 50°F. and the air to be conditioned is blown past them. Such coils constitute a considerable refrigeration load. Refrigerated coils serve as dehumidifiers of the air circulating past them (if the humidity is high), since some of the air will be cooled below the dew point and the excess moisture will be condensed

out on the coils. This leaves the conditioned air both cooler and dryer; since both of these are important factors in summer air-conditioning, neither factor needs to be carried to the extreme. Naturally, adequate drains must be provided to carry away the moisture condensed on the cooling coils. Some air-conditioning plants use ice for the cooling medium, particularly if cooling is only needed for a comparatively few days of the year. Cold water from streams or wells may also be used for the cooling coils. However, the more common air-conditioning installations use automatic refrigeration as the cooling means.

462. AIR CLEANING AND FILTERING EQUIPMENT:

This equipment usually consists of dry or moist filters of fibrous material through which the air is forced; the fibrous material collects out the particles of dust and other harmful ingredients. Water sprays are often used to clean the air. These sprays may also serve to either humidify the air or dehumidify the air to some extent. In the winter time water sprays, if they are kept fairly warm, will add considerable moisture to the dry air; in the summer time if the spray water is kept cold it will tend to take moisture out of the air and in this way dry the air. Therefore, it serves the humidifying, dehumidifying, and cleaning purpose.

Most air cleaning and filtering equipment must be cleaned periodically if it is to be efficient.

463. HUMIDIFYING AND DEHUMIDIFYING EQUIPMENT:

Humidifying equipment usually consists of a heated water surface over which the conditioned air is forced to pass and moisture is picked up from the surface, depending upon the degree of humidifying required. Dehumidifying equipment

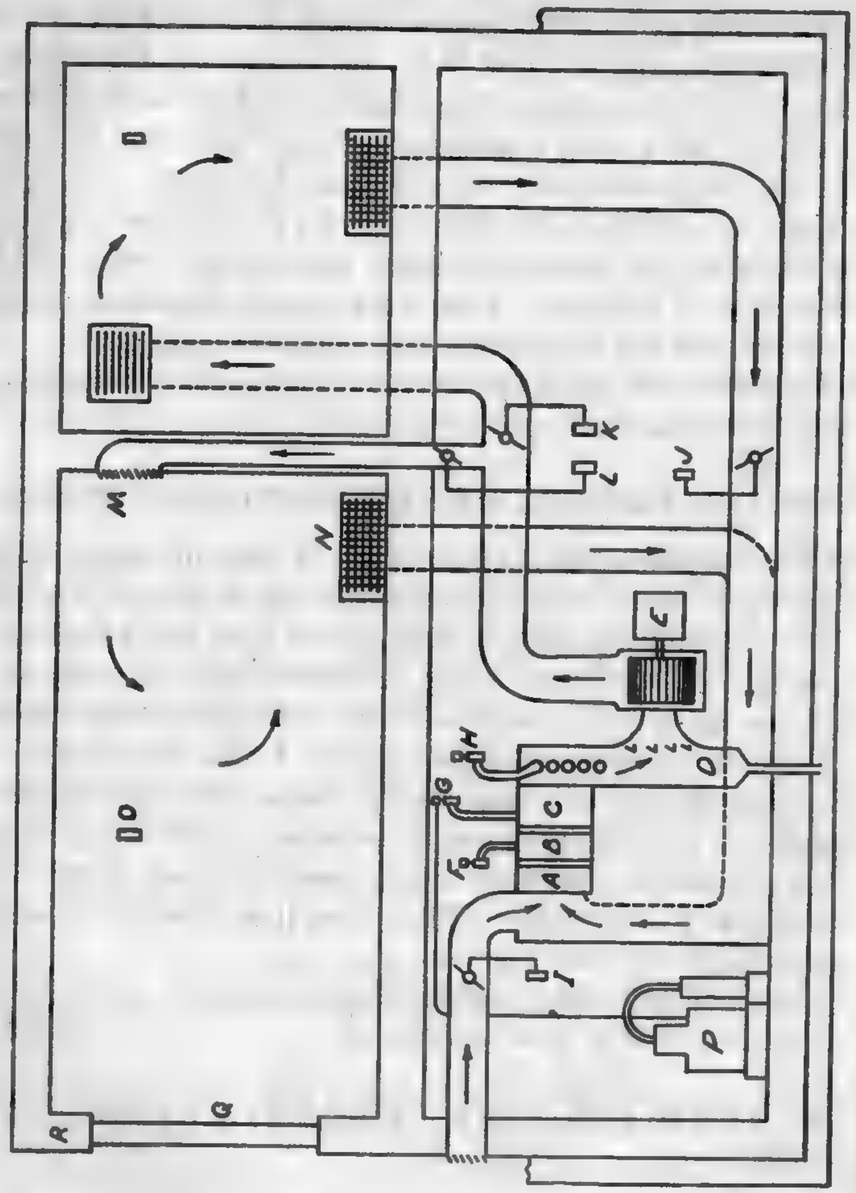


Fig. 325. A typical central or duct air conditioning plant
A. Filter; B. Heating coil; C. Cooling coil; D. Eliminator plates and moisture drain; E. Centrifugal fan and motor; F. Heat control and shut-off; G. Refrigerant control and shut off; H. Water spray control and shut off; I. Fresh air control; J. Return air control and damper; K. and L. Conditioned air dampers and controls; M. Conditioned air inlet; N. Return air register; O. Room control; P. Refrigerating unit; Q. Double window; R. Insulated wall

consists of cold coil surfaces over which air is blown and the moisture is condensed out by coming in contact with the cold coils. In some installations, certain chemicals are used which have the property of absorbing moisture from the air. In case chemicals are used, the chemicals are usually cycled in such a way that moisture from the air is absorbed. Then the chemicals are heated, and the moisture is driven out-of-doors so that the chemicals will be in condition to absorb more moisture.

It should be remembered that most air-conditioning installations are engineering problems and that adequate calculations and specifications must be given; otherwise the system will not function satisfactorily.

The following represent some typical air-conditioning installations which seem satisfactory:

464. THE CENTRAL AIR-CONDITIONING PLANT:

Figure 325 illustrates a conventional duct air-conditioning system in which the entire plant is located in the basement and the conditioned air is circulated through ducts to the various rooms. Large plants of this type usually generate steam in the heating plant which then circulates through coils in the air-conditioner for heating purposes. Small plants such as those used in small and medium sized homes may be of the direct heating type in which heating of the air is accomplished directly from the furnace. In this case, accurate controls of the furnace fire are necessary. The refrigeration plant for summer cooling usually uses a water cooled condensing unit. These coils also dehumidify the air, and provision is made to drain away the moisture condensed from the air. Figure 326 illustrates a duct system used in a small home in which direct air heating is employed.

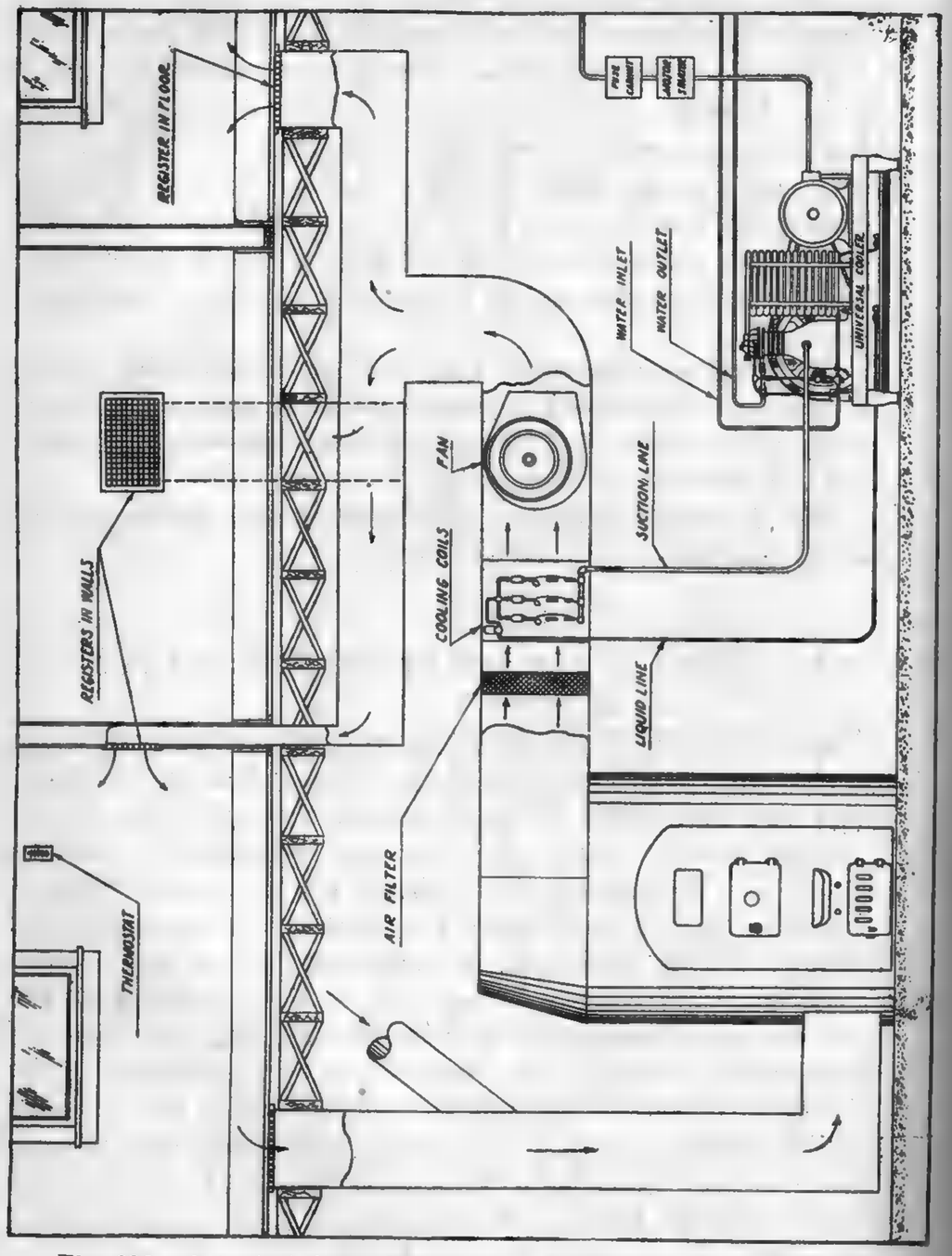


Fig. 326. A typical direct heating duct installation for a small home
(Courtesy of: Universal Cooler Corporation)

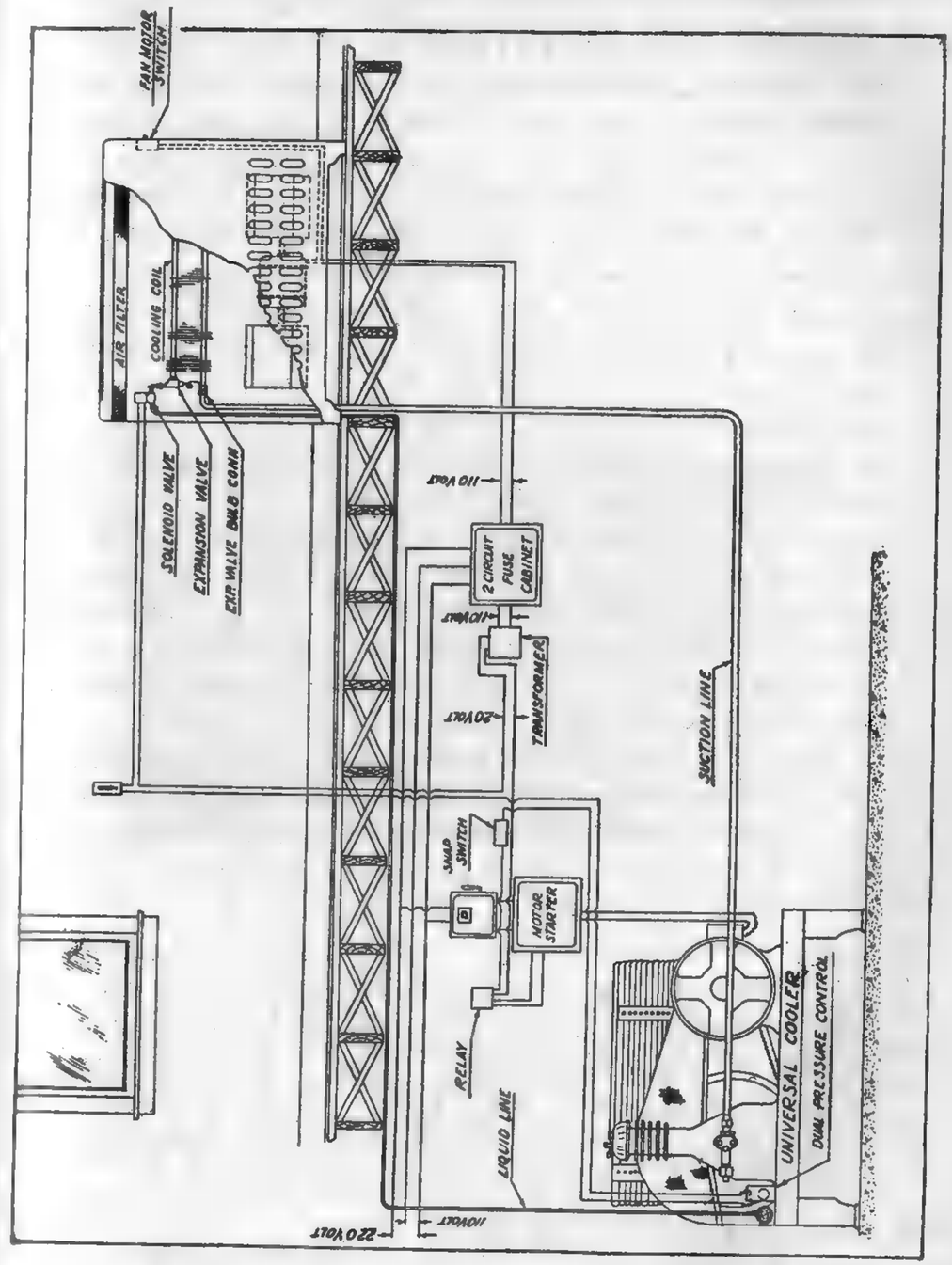


Fig. 327. A remote air-conditioning plant
(Courtesy of: Universal Cooler Corporation)

465. REMOTE AIR-CONDITIONING PLANT:

The remote air-conditioning plant provides a central heating plant (steam) and a central refrigerating plant in the basement. The heating and refrigeration lines are then run to air-conditioning units in each room to be air-conditioned. Figure 327 illustrates a remote air-conditioning plant. Such an installation operates with a pressure motor control on the condensing unit. Individual thermostats are connected in each room to each air-conditioning room unit. A solenoid switch controls the refrigerant flow to the unit; this is connected to the room temperature control, which controls both a fan and a solenoid refrigerant valve in the room unit in such a manner that liquid refrigerant to the room unit is turned on when the fan starts in the unit and is shut off when the fan stops. Some units use a thermostat to control the refrigerant solenoid valve only, while the fan runs continuously. A thermostatic expansion valve refrigerant control is usually used. In large installations, multiple coils and several expansion valves are used.

Since the cooling coils are located in the room which is being air-conditioned, provision must be made to dispose of the moisture condensed out of the air in the summer time. This is usually accomplished by connecting the unit to a water drain by means of ½-inch copper pipe.

Inasmuch as these units serve both summer and winter conditions, a change-over switch is located in the system to change it from summer cooling to winter heating or the reverse, as the needs demand. Some systems are arranged to switch over automatically by the use of an outdoor thermostat which works in co-operation with the indoor thermostat. Air filters must be provided in these units.

466. UNIT AIR-CONDITIONERS:

Unit air-conditioners are of two types: (1) one type provides only comfort cooling for summer; (2) the other type provides both summer cooling and winter heating. Both types have a complete refrigeration plant included in them, i.e., condensing unit, refrigerant valves, and cooling coils. Individual room thermostats control the unit. Filtering equipment is also a part of the system. Since most of the condensing units are water-cooled, it is necessary to make these water connections in order to install them. These lines consist of a water in, a water out, and a low pressure water

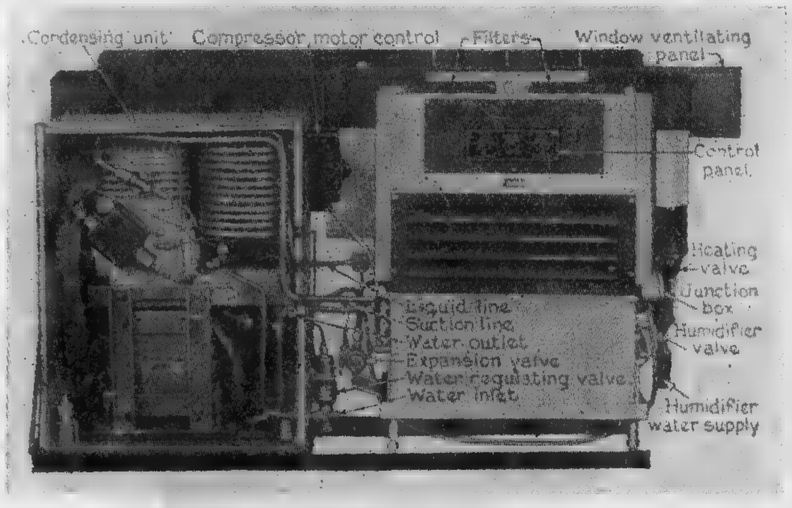


Fig. 328. A unit air conditioner with the front panel removed to show the interior construction
(Courtesy of: General Electric Company)

drain to take care of the moisture condensed out of the air by the cooling coil in the summer time. One company has developed a special three-flue rubber hose for this purpose which permits moving the unit quickly from room to room. Such a unit does not provide winter conditioning facilities. Figure 328 illustrates one of these units.

467. AIR-CONDITIONING CONTROLS:

The chief value of complete air-conditioning lies in its accu-

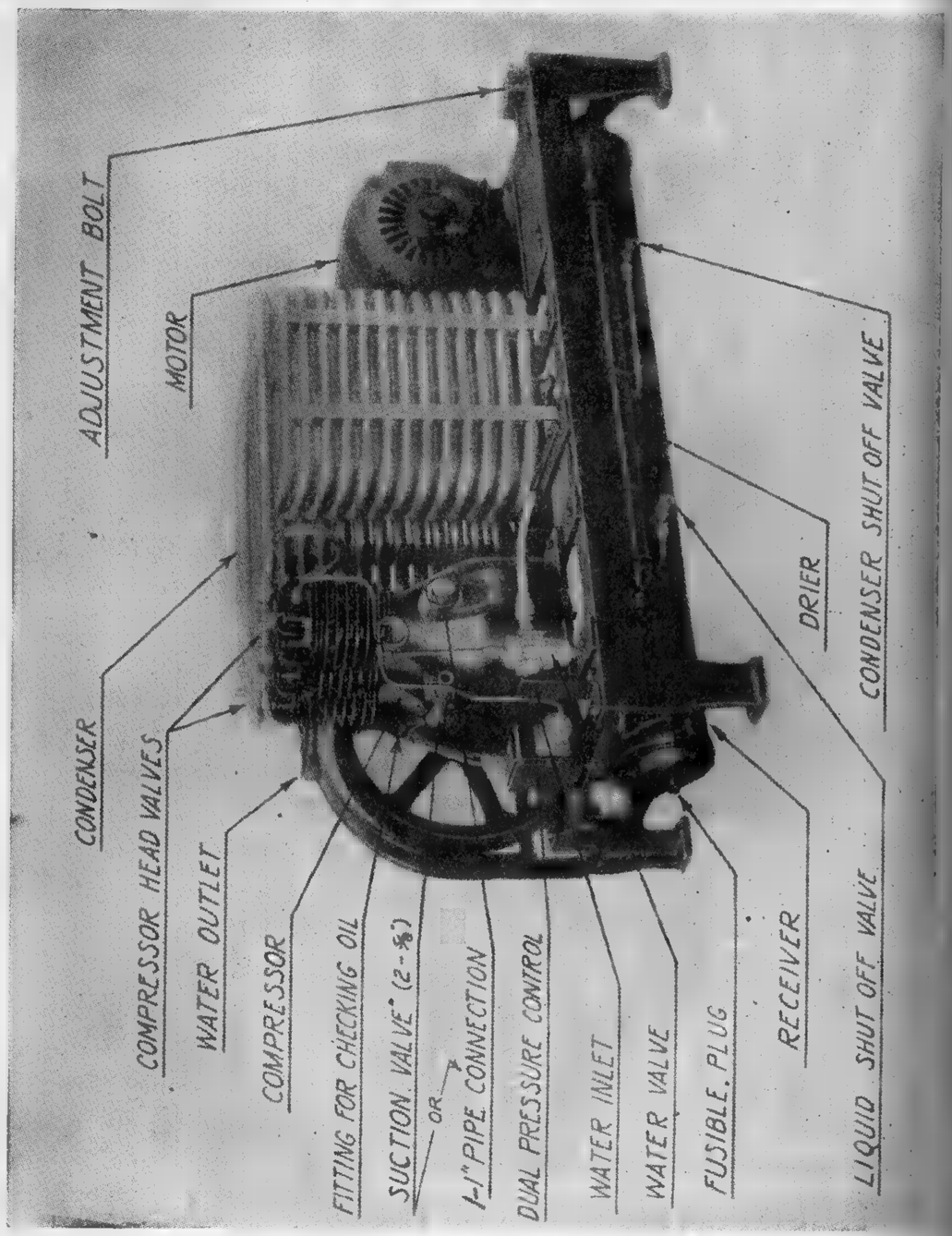


Fig. [illegible]. **A typical air conditioning condensing unit and controls**
(Courtesy of: Universal Cooler Corporation)

rate automatic operation. This necessitates many controls. Figure 329 illustrates an air-conditioning installation and the controls are indicated. These controls include the heating controls such as source of heat, low water (safety) control, water flow control valve through the refrigerator condenser, pressure motor control which controls the condensing unit, humidity control, room temperature control, and the

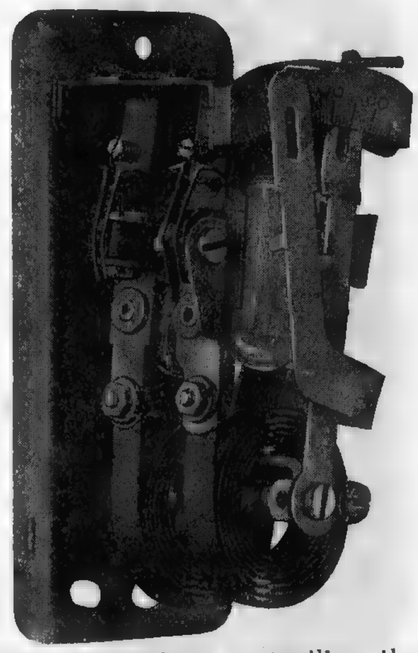


Fig. 330. **A combination temperature controlling thermostat for controlling both heating and cooling devices**
(Courtesy of: Mercoid Corporation)

switch-over control which changes the unit from summer to winter conditions.

468. TEMPERATURE CONTROLS:

Temperature controls used on air-conditioning plants vary somewhat from the type used on refrigeration installations. Two different types of controls are used, bimetal and vapor pressure controls being the most popular. Figure 330 illus-

trates a combination thermostat which may be used for controlling both the heating and cooling service. These thermostats usually operate on a 1° to 2°F. differential, which results in close temperature control if the room is being air-conditioned. In comfort-cooling installations, for summer

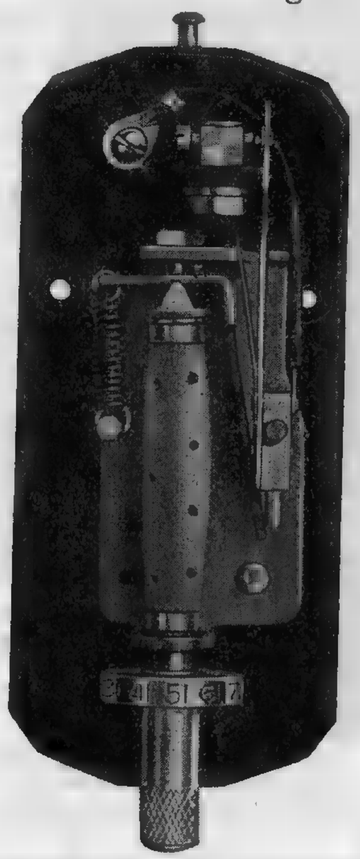


Fig. 331. A humidity regulator showing operating mechanism
(Courtesy of: Automatic Products Company)

cooling, the accuracy of temperature control is not quite so important as that used in connection with winter heating. Such thermostats should be placed on inside walls and away from registers, radiators, or places where outside drafts will strike them. It is important that the air be allowed to circu-

late freely around temperature controls, so they should not be placed where home furnishings are likely to interfere with this circulation.

It is ■ common practice to shut off the service not needed; such as in the winter time when the cooling system is not needed, a separate manual switch should be provided to positively open this circuit so that it can not start.

469. HUMIDITY CONTROLS:

Humidity controls are important in keeping the relative humidity of the air-conditioned rooms satisfactory. Most humidity controls operate during periods of winter heating, add moisture to the air, and keep the humidity approximately constant. Such controls usually operate electrically to regulate jaws or dampers. The control element is usually wood which is sensitive to the amount of moisture in the air. Figure 331 illustrates the interior construction of a popular humidity control device. Health studies indicate that humidity control is ■ very important factor in air-conditioning for the winter time. Also adequate filtering of the air is important for health.

470. REFRIGERANT CONTROLS:

Air-conditioning cooling coils usually use the thermostatic expansion valve refrigerant control. Some installations use several such expansion valves on one large coil in order to get the maximum efficiency from the coil.

In addition to the thermostatic expansion valves another refrigerant control is usually put in the coils. This consists of a solenoid refrigerant valve placed in the liquid line, and it automatically stops the flow of refrigerant to the coil the instant the condensing unit stops. This is necessary in order that the cooling coil will not become flooded with refrigerant

while the condensing unit is idle. Figure 332 illustrates a typical solenoid refrigerant control valve.

471. REVIEW QUESTIONS:

Answers to the following questions may be found on page 835.

1. How is human comfort affected by temperature and humidity?

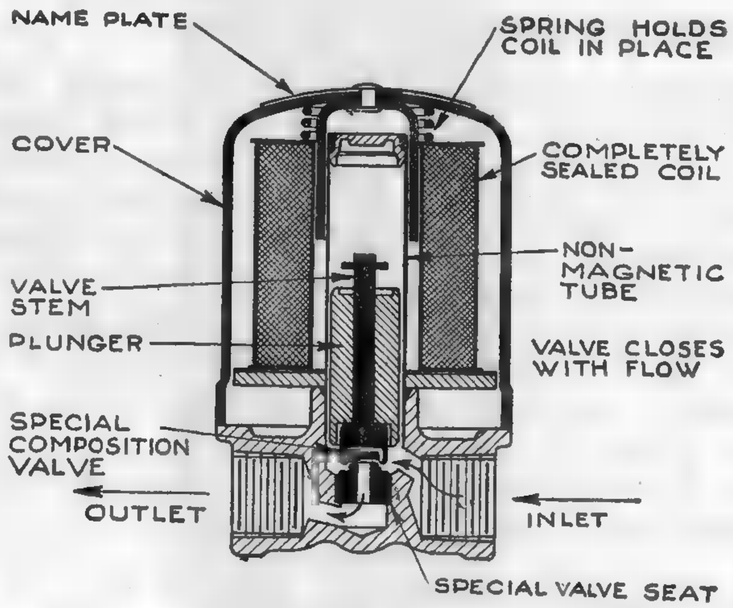


Fig. 332. A cross section of a solenoid refrigerant control used on air conditioning coils
(Courtesy of: Automatic Products Company)

2. Does winter humidity tend to be too high or too low?
3. What is the meaning of the relative humidity?
4. How is humidity measured?
5. What is a psychrometric chart?
6. Name the important parts of an air-conditioning plant.
7. What is "effective temperature"?
8. Why is filtering equipment necessary?

9. How is humidity usually added when needed?
10. How is the humidity of conditioned air decreased?
11. Name three types of air-conditioning plants.
12. What refrigerant controls are usually used on air-conditioning cooling coils?
13. Why are solenoid refrigerant control valves necessary on air-conditioning cooling coils?
14. What are the insulating requirements for air-conditioned structures?
15. What industries have used air-conditioning in their plants for some time?

CHAPTER XIX

DOMESTIC REFRIGERATOR SPECIFICATIONS

The tables of specifications which follow are compiled to give the student certain pertinent data necessary in service work. The specifications are divided into three portions: (1) the specification tables; (2) illustrations of parts of the mechanism; and (3) footnotes on repair pointers and explanations of certain parts of the specifications.

The specifications are necessarily abbreviated and the following abbreviations are used:

Con. = Conventional
Herm. = Hermetic
S.H. = Semi-hermetic
Recip. = Reciprocating
Rtry. = Rotary
B = Belt drive
D = Direct drive
G = Gear drive
SO_2 = Sulphur dioxide
M.C. = Methyl chloride
Iso-B. = Iso-butane
Eth. Chl. = Ethyl chloride
M. For. = Methyl formate
Car. = Carrene = Methylene chloride
Ex. V. = Expansion valve
L.S.F. = Low side float
H.S.F. = High side float
Cap. T. = Capillary tube
Th. E. V. = Thermostatic expansion valve
Therm. = Thermostatic
Porc. = Porcelain
S.S. = Stainless Steel

Where the amount of oil is marked in ounces this means fluid ounces not avoirdupois ounces, the latter being used to measure refrigerant quantities.

Note: The specification notes are numbered to correspond with the specification tables appearing later in this chapter.

SPECIFICATION NOTES

472. This compressor may only run clockwise.

474. This unit is one of the first domestic refrigerators to use a thermostatic expansion valve as a refrigerant control.

476. *Oil filled hold-over tanks are used on the cooling units of these models.

The crankshaft seal may be flushed by using two very thin pieces of wood to pry the seal ring from the seal face when the unit is running.

The motors must be aligned very carefully in the models prior to 1935.

The expansion valve may be adjusted to the correct setting by freezing a thermometer on the bottom shelf and set it between 3°F. and 10°F. (the older models use the higher temperature; see Specifications).

478. Never remove the rotary compressor cylinder from the base of the compressor.

The refrigerant charge is determined by the presence of frost on the suction line (frost on the suction line indicates too much refrigerant).

479. The float mechanism is adjustable on some models by means of an external valve stem adjustment.

480. Models B-1 and B-2 are mounted in the base of the cabinet.

Models A-4 and A-6 are package units mounted in the top of the cabinet.

481. *This amount of refrigerant stays in the condensing unit, the low side float chamber uses 2 pounds to 5 pounds more to complete the charge of the unit. The oil charge in the cooling unit is from 4 ounces to 8 ounces.

†These systems use a weight check valve located on the cooling coil, permitting the location of the high side float on the condensing unit.

482. *The reciprocating compressor uses an oscillating cylinder to eliminate the usual connecting rod.

483. *The quantity of refrigerant varies with the size of the cabinet. Check the frost formation on the suction line to determine the correct amount of charge.

484. The compressor is a horizontal, opposed, two cylinder type. The two pistons are made in one piece and are driven by a Scotch yoke drive.

485. The oil and refrigerant may be poured in through the gauge attachment on the high side float chamber.

To check the refrigerant charge, hold the high side float down with an electromagnet and the refrigerant should fill the high side float chamber up to the gauge opening.

*Both high side floats and capillary tubes (Carrene meters) were used in the "H" models.

487. *This model is a dome type compressor.

The model AA unit does not use either the oil return separator or a dehydrator.

489. This unit is the package type and uses suction ports rather than intake valves. The motor used is the capacitator type. The unit is equipped with the three typical service valves.

491. "A" is the key to represent air-cooled models. "B" is the key to represent water-cooled models.

* The kind of installation determines these three valves.

493. An electromagnet may be used to operate the high side float ball. The fan motor consumes approximately 25 watts.

496. The cooling coils on all but the very earliest models are not equipped with servicing valves. The "Rollator" when removed must be purged to remove the sulphur dioxide dissolved in the high pressure oil. Heating the compressor housing carefully before doing this will force most of the refrigerant into the condenser.

497. This unit uses a thermostatic expansion valve.

498. *Potter DeLuxe models are unique in that they are divided into two separate, fully insulated compartments—the lower for freezing service and frozen food storage, the upper "air-conditioned" for general food preservation.

The refrigeration cycle is automatically induced by a thermostat in the upper compartment. The refrigerant first circulates through the freezing grid to refrigerate the lower compartment, the surplus passing on to the finned (upper) coil to bring the food storage compartment to its proper 40° level. The isolation of freezing and cooling operations enables the manufacturer to provide constant sub-zero freezing temperatures in the lower compartment and at the same time maintain proper temperatures with high relative humidity in the upper compartment. This humidification or "air-conditioning," as explained by the manufacturer, prevents spoilage of foods through dehydration.

499. The unit must be charged with a carefully measured amount of refrigerant. Too much refrigerant will make the unit frost back, while not enough refrigerant will prevent efficient refrigeration. The filter installed prior to the capillary tube must be kept in excellent condition or a clogged capillary tube will result.

500. Streamline tubing connections are used on the earlier models.

The 1935 models may run clockwise only.

The 1935 models use a 1½-inch to 1¾-inch depth of oil in the crankcase.

502. The 1934 model used a top mounted unit which was completely equipped with the conventional servicing valves.

The 1934 and 1935 units use an electrical clock connected into the system to automatically defrost and start the unit again each day if desired.

504. From 2 to 4 ounces of the refrigerant oil charge will always be in the cooling coil.

The thermostat power bulb is installed in a cavity built into the cooling coil header.

The oil level plug is provided with an oil depth indicator rod, while the cooling coil is equipped with two servicing valves.

The 1935, 1 cylinder model compressor should build up 90 pound per square inch head pressure in 1 minute with the low side pressure at 6 in. of vacuum.

The 1935, 2 cylinder model compressor should build up a 125 pound per square inch gauge head pressure in 2 minutes with the low side pressure at 6 inch of vacuum. The compressor should be cold when the test is started.

505. The expansion valve in all but the 1935 model should be adjusted to give a 12°F. to 13°F. cooling coil. A service valve attachment is needed to service all but the 1935 models. These earlier models are top-mounted units. The 1935 model is a conventional unit mounted in the base of the cabinet. A 1½-inch to 1¾-inch depth of oil should be maintained in the crankcase of the 1935 compressor.

506. The compressor may run clockwise only.

507. The compressor may run clockwise only. A 1½-inch to 1¾-inch oil level depth must be maintained in the crankcase of the compressor.

508. The discharge valve acts as the check valve due to the construction of the compressor.

509. The unit is the only domestic gasoline engine driven refrigerator. The gasoline engine and the compressor are built in one assembly using a common shaft.

510. Although the unit is not manufactured at present, parts may be procured from the company.

511. This system uses a solenoid operated compressor unloader valve as illustrated in Figure 367.

The extra motor necessary to drive the condenser fan is a two-phase motor which uses current built up in the compressor motor. This current built up in the motor would otherwise be wasted and it enables the fan motor to function with the use of only approximately 10 watts from the line.

512. The high side pressure gauge is mounted on the liquid receiver service valve rather than on the discharge service valve.

REFRIGERATOR SPECIFICATIONS WILL BE FOUND IN THE FOLLOWING PARAGRAPHS:

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Waukesha 509
Welsbach 510
Westinghouse 511
White Mountain 512
Zerozone 513

472. ABSOPURE

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure	Quantity of Refrigerant	Refrigerant Control	Quantity of Oil	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
1927	.....	Con.	Recip.	1	B	⅛	M. C.	.....	.....	2#	Ex. Va.	1 pt.	Therm.	.....	Brine	....
1928	.....	Con.	Recip.	1	B	⅛	M. C.	.....	.....	2#	Ex. Va.	1 pt.	Therm.	.....	Brine	....
1929	.....	Con.	Recip.	1	B	⅛	M. C.	.....	.....	2#	Ex. Va.	1 pt.	Therm.	.....	Brine	....

473. APEX—APEX ELECTRIC MANUFACTURING CO., CLEVELAND, OHIO

	L-410	Con.	Recip.	1	B	⅛	SO_2	.....	.....	1½#	Ex. Va.	14 oz.	Therm.	.....	Brine	....
	L-610	Con.	Recip.	1	B	⅛	SO_2	.....	.....	1½#	Ex. Va.	14 oz.	Therm.	.....	Brine	....
	L-500	Con.	Recip.	1	B	⅛	SO_2	.....	.....	4#	L.S.F.	14 oz.	Therm.	.....	Porc.	....
	L-600	Con.	Recip.	1	B	⅛	SO_2	.....	.....	4½#	L.S.F.	14 oz.	Therm.	.....	Porc.	....
	P-600	Con.	Recip.	1	B	⅛	SO_2	.....	.....	4½#	L.S.F.	14 oz.	Therm.	.....	Porc.	....
	L-800	Con.	Recip.	1	B	¼	SO_2	.....	.....	5#	L.S.F.	14 oz.	Therm.	.....	Porc.	....
	P-800	Con.	Recip.	1	B	¼	SO_2	.....	.....	5#	L.S.F.	14 oz.	Therm.	.....	Porc.	....
1935	740	Con.	Recip.	1	B	⅛	SO_2	.....	.....	4#	Cap. T.	7 oz.	Therm.	.....	Porc.	....
	760	Con.	Recip.	1	B	⅛	SO_2	.....	.....	4½#	Cap. T	7 oz.	Therm.	.....	Porc.	....
	745	Con.	Recip.	1	B	⅛	SO_2	.....	.....	4#	L.S.F.	7 oz.	Therm.	.....	Porc.	....
	SSL6	Con.	Recip.	1	B	⅛	SO_2	.....	.....	4½#	L.S.F.	7 oz.	Therm.	.....	Porc.	....
	SSL7	Con.	Recip.	1	B	⅛	SO_2	.....	.....	5#	L.S.F.	7 oz.	Therm.	.....	Porc.	....
	DTL6	Con.	Recip.	2	B	⅛	SO_2	.....	.....	4½#	L.S.F.	11 oz.	Therm.	.....	Porc.	....
	DTL7	Con.	Recip.	2	B	⅛	SO_2	.....	.....	5#	L.S.F.	11 oz.	Therm.	.....	Porc.	....
	DTL8	Con.	Recip.	2	B	⅛	SO_2	.....	.....	5¼#	L.S.F.	11 oz.	Therm.	.....	Porc.	....

474. ATWATER-KENT—ATWATER-KENT MFG. CO., PHILADELPHIA, PA.

1935	R-10	Con.	Recip.	1	B	⅛	M. C.	.....	.....	1#	T.E.V.	5 oz.	Therm.	.....	Tube	....
1935	R-20	Con.	Recip.	1	B	⅛	M. C.	.....	.....	1#	T.E.V.	5 oz.	Therm.	.....	Tube	....

475. BUCKEYE—DOMESTIC INDUSTRIES, MANSFIELD, OHIO

	44	Con.	Recip.	1	B	⅛	SO_2	.....	.....	1½#	Ex. Va.	10 oz.	Therm.	.....	Tube	....
	53	Con.	Recip.	1	B	⅛	SO_2	.....	.....	1½#	Ex. Va.	10 oz.	Therm.	.....	Tube	....
	71	Con.	Recip.	1	B	⅛	SO_2	.....	.....	2#	Ex. Va.	10 oz.	Therm.	.....	Tube	....
1933	.....	Con.	Recip.	1	B	⅛	SO_2	.....	.....	.....	Ex. Va.	.....	Therm.	.....	Tube	....
1934	L-60	Con.	Recip.	1	B	⅛	SO_2	.....	.....	2#	Ex. Va.	12 oz.	Therm.	.....	Tube	....
1935	600	Con.	Recip.	1	B	⅛	SO_2	.....	.....	2#	Cap. T.	13 oz.	Therm.	.....	Shell	....

476. COLDSPOT—SEARS, ROEBUCK COMPANY, CHICAGO, ILL.

1930	A	S.H.	Rtry.	...	D	⅛	SO_2	.....	9″	1½ to 2#	Ex. Va.	1 pt.	Therm.	.....	.....	....
1930	B	S.H.	Rtry.	...	D	⅛	SO_2	.....	8″	1½ to 2#	Ex. Va.	1 pt.	Therm.	.....	.....	....
1930	C	S.H.	Rtry.	...	D	⅛	SO_2	.....	7″	1½ to 2#	Ex. Va.	1 pt.	Therm.	.....	.....	....
1931	D	S.H.	Rtry.	...	D	⅛	SO_2	.....	9″	1½ to 2#	Ex. Va.	1 pt.	Therm.	.....	.....	....
and	E	S.H.	Rtry.	...	D	⅛	SO_2	.....	8″	1½ to 2#	Ex. Va.	1 pt.	Therm.	.....	Tube	....
1932	F	S.H.	Rtry.	...	D	⅛	SO_2	.....	7.5″	1½ to 2#	Ex. Va.	1 pt.	Therm.	.....	Tube	....
	G	S.H.	Rtry.	...	D	¼	SO_2	.....	7.5″	1½ to 2#	Ex. Va.	1 pt.	Therm.	.....	Tube	....
1933	DA	S.H.	Rtry.	...	D	⅛	SO_2	.....	8″	1½ to 2#	Ex. Va.	1 pt.	Therm.	.....	Tube	....
1933	EA	S.H.	Rtry.	...	D	⅛	SO_2	.....	8″	1½ to 2#	Ex. Va.	1 pt.	Therm.	.....	Tube	....
1933	FA	S.H.	Rtry.	...	D	⅛	SO_2	.....	8″	1½ to 2#	Ex. Va.	1 pt.	Therm.	.....	Tube	....
1933	GA	S.H.	Rtry	...	D	¼	SO_2	.....	7″	1½ to 2#	Ex. Va.	1 pt.	Therm.	.....	Tube	....
1934	J	S.H.	Rtry.	...	D	⅛	SO_2	.....	9″	1½ to 2#	Ex. Va.	1 pt.	Therm.	.....	Tube	....
1934	K	S.H.	Rtry.	...	D	⅛	SO_2	.....	8″	1½ to 2#	Ex Va.	1 pt.	Therm.	.....	Tube	....
1934	L	S.H.	Rtry.	...	D	⅛	SO_2	.....	7.5″	1½ to 2#	Ex. Va.	1 pt.	Therm.	.....	Tube	....
1934	M	S.H.	Rtry.	...	D	¼	SO_2	.....	7″	1½ to 2#	Ex. Va.	1 pt.	Therm.	.....	Tube	....
1935	T	S.H.	Rtry.	...	D	⅛	SO_2	.....	9″	1½ to 2#	Ex. Va.	1 pt.	Therm.	.....	Tube	....
1935	W	S.H.	Rtry.	...	D	⅛	SO_2	.....	8″	1½ to 2#	Ex. Va.	1 pt.	Therm.	.....	Tube	....
1935	Y	S.H.	Rtry.	...	D	⅛	SO_2	.....	8″	1½ to 2#	Ex. Va.	1 pt	Therm.	.....	Tube	....
1935	Z	S.H.	Rtry.	...	D	¼	SO_2	.....	7″	1½ to 2#	Ex. Va.	1 pt.	Therm.	.....	Tube	....

477. COPELAND—COPELAND REFRIGERATOR CORP., DETROIT, MICH.

1921 1922	A	Con	Recip	1	B	⅛	Freezol	.....	.....	1#	Ex. Va.	1 pt.	Therm.	.....	Brine	....
1922 1923	B	Con.	Recip.	1	B	⅛	Freezol	.....	.....	1#	Ex. Va.	1 pt.	Therm.	.....	Brine	....

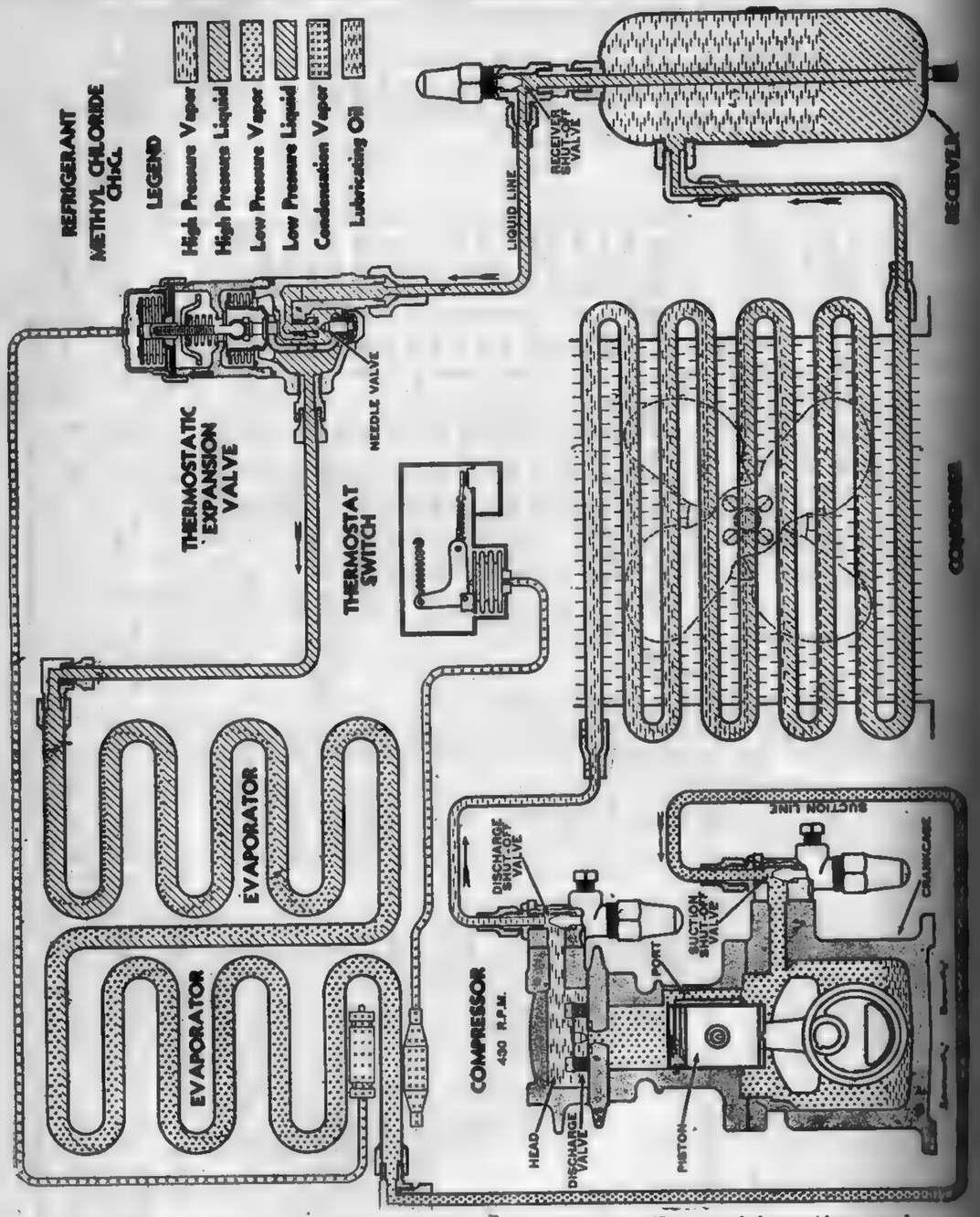


Fig. 333. A diagrammatic sketch of the Atwater Kent refrigeration cycle. Note the thermostatic expansion valve
(Courtesy of: Atwater-Kent Company)

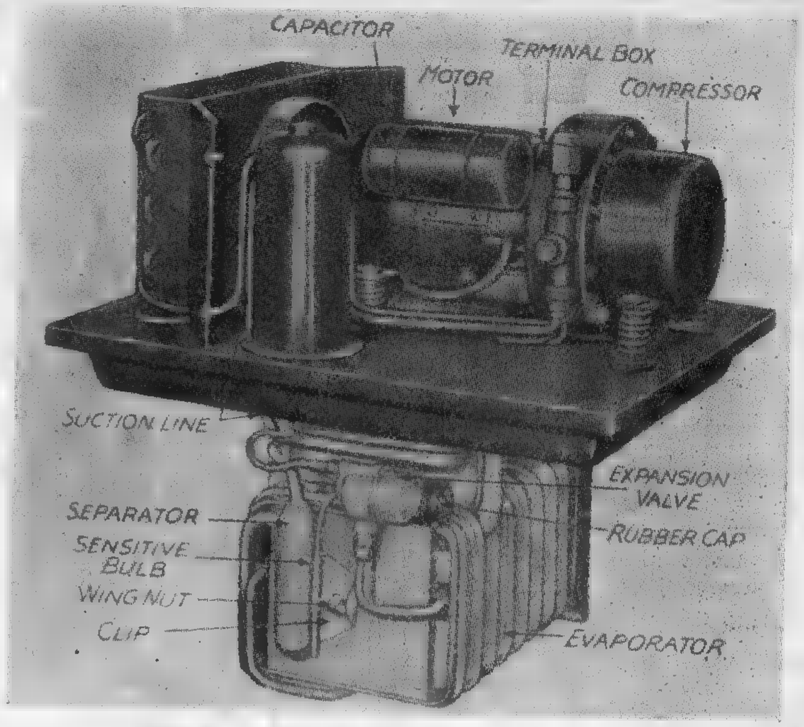


Fig. 334. The Coldspot condensing unit
(Courtesy of: Sunbeam Electric Manufacturing Company)

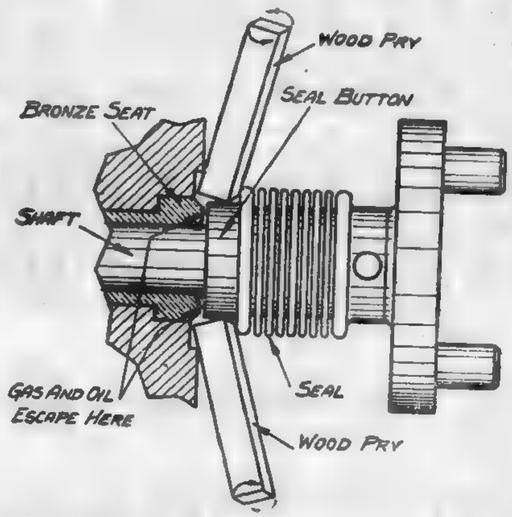


Fig. 335. Illustrating how the Coldspot crankshaft seal is flushed
(Courtesy of: Sunbeam Electric Manufacturing Company)

477. COPELAND, Continued

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure	Quantity of Refrigerant	Refrigerant Control	Quantity of Oil	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
1922	C	Con.	Recip.	1	B	⅛	Freezol	.....	.....	1#	Ex. Va.	1 pt.	Therm.	.....	Brine	....
1923																
1924	D	Con.	Recip.	1	B	⅛	Freezol	.....	.....	1#	Ex. Va.	1 pt.	Therm.	.....	Brine	....
1926																
1926	215	Con.	Recip.	1	B	⅛	Freezol	.....	.....	1¼#	Ex. Va.	1¼ pt.	Therm.	.....	Brine	....
1927																
1927	F	Con.	Recip.	1	B	⅛	Freezol	.....	.....	1¼#	Ex. Va.	⅞ pt.	Therm.	.....	Brine	....
1928																
1927	G	Con.	Recip.	1	B	⅛	Freezol	.....	.....	1¼#	Ex. Va.	⅞ pt.	Therm.	.....	Brine	....
1928																
1926	H	Con.	Recip.	1	B	⅛	Freezol	.....	.....	1½#	Ex. Va.	⅞ pt.	Therm.	.....	Brine	....
1929																
1929	I	Con.	Recip.	1	B	⅛	Freezol	.....	.....	1¼#	Ex. Va.	⅞ pt.	Therm.	.....	Brine	....
1929	O	Con.	Recip.	1	B	⅛	Freezol	.....	.....	1¼#	Ex. Va.	⅞ pt.	Therm.	.....	Brine	....
1928	N	Con.	Recip.	1	B	⅛	Freezol	.....	.....	⅞#	Ex. Va.	⅞ pt.	Therm.	.....	Brine	....
1929																
1929	A-5	Con.	Recip.	1	B	⅛	Freezol	.....	.....	⅞#	Ex. Va.	⅞ pt.	Therm.	.....	Brine	....
1930	#1	Con.	Recip.	1	B	⅛	Freezol	.....	.....	1 1/16#	Ex. Va.	⅞ pt.	Therm.	.....	Brine	....
1930	#2	Con.	Recip.	2	B	¼	Freezol	.....	.....	1 1/16#	Ex. Va.	1¾ pt.	Therm.	.....	Brine	....
1931	#1	Con.	Recip.	1	B	⅛	Freezol	.....	.....	1 1/16#	Ex. Va.	⅝ pt.	Therm.	.....	Brine	....
1931	#2	Con.	Recip.	2	B	¼	Freezol	.....	.....	1 1/16#	Ex. Va.	1¾ pt.	Therm.	.....	Brine	....
1932	....	Con.	Recip.	2	B	⅛	Freezol	.....	.....	1 1/16#	Ex. Va.	1¾ pt.	Therm.	.....	Brine	....
1933	....	S.H.	Recip.	1	D	⅛	M. C.	.....	.....	5½ oz.	Ex. Va.	1¾ pt.	Therm.	.....	Tube	....
1934	....	Con.	Recip.	1	B	⅛	M. C.	.....	.....	1#	Ex. Va.	¾ pt.	Therm	.....	Porc.	....
1935	....	Con.	Recip.	1	B	⅛	M. C.	.....	.....	1#	Ex. Va.	¾ pt.	Therm.	.....	Porc.	....
1936	....	Con.	Recip.	2	B	...	.....	.....	.....	.....	.....	.....	.....	.....	.....	....

478. CROSLEY—THE CROSLEY RADIO CORPORATION, CINCINNATI, OHIO

1932	20	Con.	Recip.	1	B	⅛	SO_2	.....	.....	21 oz.	Cap. T.	15 oz.	Therm.	.....	Porc.	....
	16	Con.	Recip.	1	B	⅛	SO_2	.....	.....	27 oz.	Cap. T.	15 oz.	Therm.	.....	Porc.	....
	14	Con.	Recip.	1	B	⅛	SO_2	.....	.....	34 oz.	Cap. T.	15 oz.	Therm.	.....	Porc.	....
1933	29	Con.	Recip.	1	B	⅛	SO_2	.....	.....	27 oz.	Cap. T.	15 oz.	Therm.	.....	Porc.	....
	30	Con.	Recip.	1	B	⅛	SO_2	.....	.....	34 oz.	Cap. T.	15 oz.	Therm.	.....	Porc.	....
	33	Con.	Recip.	1	B	⅛	SO_2	.....	.....	34 oz.	Cap. T.	15 oz.	Therm.	.....	Porc.	....
1934	644	Con.	Recip.	1	B	⅛	SO_2	.....	.....	31 oz.	Cap. T.	15 oz.	Therm.	.....	Porc.	....
	643	Con.	Recip.	1	B	⅛	SO_2	.....	.....	34 oz.	Cap. T.	15 oz.	Therm.	.....	Porc.	....
	652	Con.	Recip.	1	B	⅛	SO_2	.....	.....	37 oz.	Cap. T.	15 oz.	Therm.	.....	Porc.	....
	640	Con.	Recip.	1	B	⅛	SO_2	.....	.....	34 oz.	Cap. T.	15 oz.	Therm.	.....	Porc.	....
	641	Con.	Recip.	1	B	⅛	SO_2	.....	.....	37 oz.	Cap. T.	15 oz.	Therm.	.....	Porc.	....
	642	Con.	Recip.	1	B	⅛	SO_2	.....	.....	40 oz.	Cap. T.	15 oz.	Therm.	.....	Porc.	....
1935	7351	Con.	Recip.	1	B	⅛	SO_2	.....	.....	.....	Cap. T.	15 oz.	Therm.	.....	Porc.	....
	7402	Con.	Recip.	1	B	⅛	SO_2	.....	.....	29 oz.	Cap. T.	15 oz.	Therm.	.....	Porc.	....
	750	Con.	Recip.	1	B	⅛	SO_2	.....	.....	30 oz.	Cap. T.	15 oz.	Therm.	.....	Porc.	....
	760	Con.	Recip.	1	B	⅛	SO_2	.....	.....	29 oz.	Cap. T.	15 oz.	Therm.	.....	Porc.	....
	7702	Con.	Recip.	1	B	⅛	SO_2	.....	.....	32 oz.	Cap. T.	13 oz.	Therm.	.....	Porc.	....
	743	Con.	Recip.	1	B	⅛	SO_2	.....	.....	30 oz.	Cap. T.	15 oz.	Therm.	.....	Porc.	....
	755	Con.	Recip.	1	B	⅛	SO_2	.....	.....	29 oz.	Cap. T.	15 oz.	Therm.	.....	Porc.	....
	770	Con.	Recip.	1	B	⅛	SO_2	.....	.....	32 oz.	Cap. T.	15 oz.	Therm.	.....	Porc.	....
	720	S.H.	Rtry.	...	D	1/16	F-21	.....	.....	20 oz.	Cap. T.	13 oz.	Therm.	.....	Porc.	....
	730	S.H.	Rtry.	...	D	1/16	F-21	.....	.....	28 oz.	Cap. T.	13 oz.	Therm.	.....	Porc.	....
	735	S.H.	Rtry.	...	D	1/16	F-21	.....	.....	28 oz.	Cap. T.	13 oz.	Therm.	.....	Porc.	....
	740	S.H.	Rtry.	...	D	1/16	F-21	.....	.....	28 oz.	Cap. T.	13 oz.	Therm.	.....	Porc.	....

479. DAYTON—DAYTON REFRIGERATOR CORP., BUFFALO, N. Y.

1932	F1-A2	Con.	Recip.	1	B	⅛	SO_2	.....	.....	3# 6 oz.	L.S.F.	1½ pt.	Therm.	.....	Porc.	....
	F1-A3	Con.	Recip.	1	B	⅛	SO_2	.....	.....	4# 6 oz.	L.S.F.	1½ pt.	Therm.	.....	Porc.	....
1933	A-2 and 3	.....	.....	...	...	...	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1934	B-2, 3 and 4	.....	.....	...	...	...	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
	CP-1147															
1935	C-2	Con.	Recip.	1	B	⅛	SO_2	.....	.....	3# 6 oz.	L.S.F.	1½ pt.	Therm.	.....	Porc.	....
	CF-147															
	C-3	Con.	Recip.	1	B	⅛	SO_2	.....	.....	4# 6 oz.	L.S.F.	1½ pt.	Therm.	.....	Porc.	....
	CF-147															

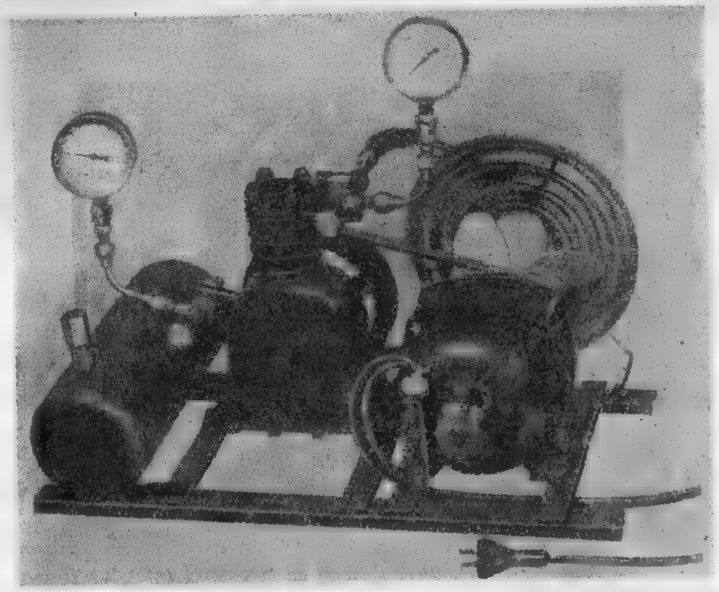


Fig. 336. The Dayton condensing unit
(Courtesy of: The Dayton Corporation)

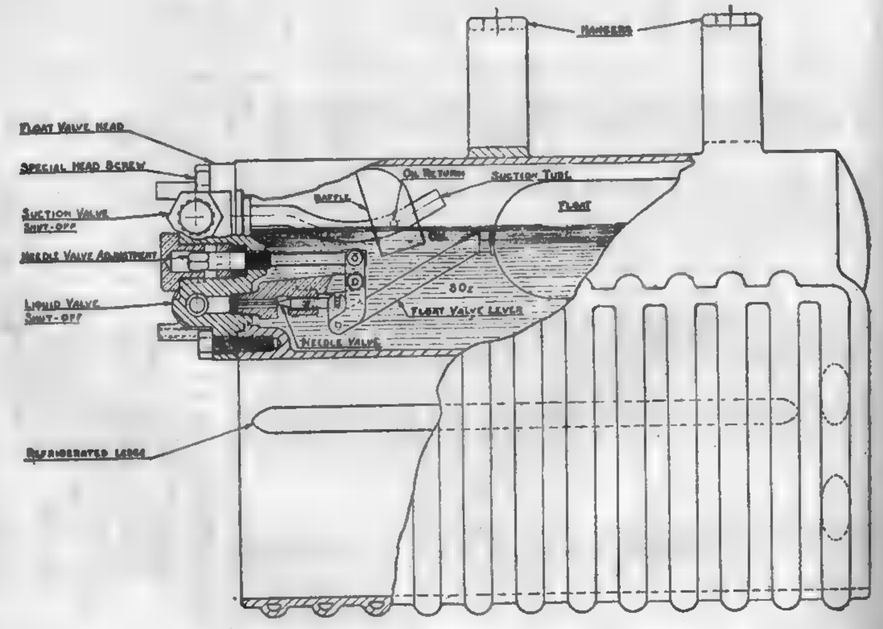


Fig. 337. The Dayton cooling coils showing the externally adjustable calibrated float
(Courtesy of: The Dayton Corporation)

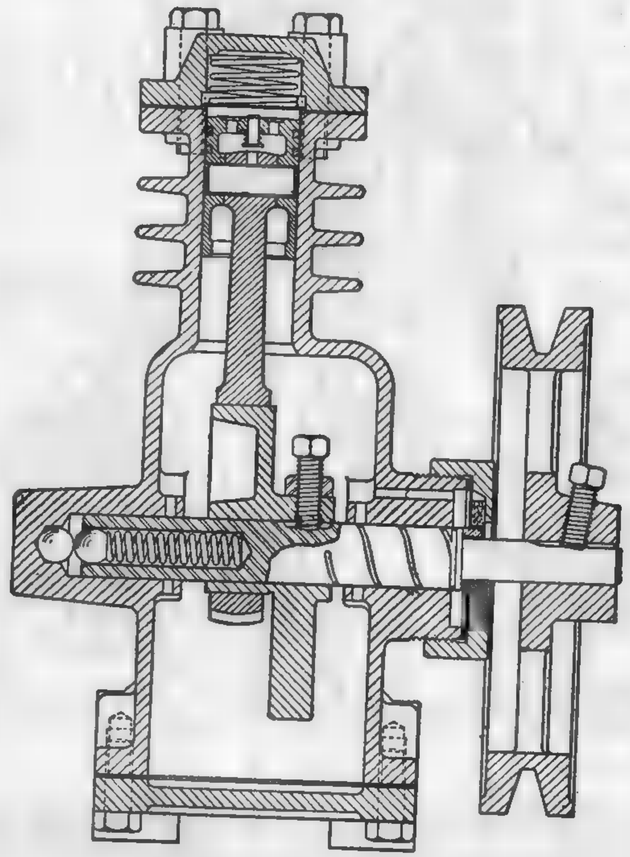


Fig. 338. The Dayton compressor
(Courtesy of: The Dayton Corporation)

479. DAYTON, Continued

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure	Quantity of Refrigerant	Refrigerant Control	Quantity of Oil	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
	C-4 CF-147	Con.	Recip.	1	B	⅛	SO_2	.....	.....	5# 6 oz.	L.S.F.	1½ pt.	Therm.	.....	Porc.	....

480. FAIRBANKS-MORSE—FAIRBANKS-MORSE HOME APPLIANCES, INC., CHICAGO, ILL.

1934	A-4	Con.	Recip.	2	D	⅛	SO_2	.....	.....	25 oz.	Ex. Va.	12 oz.	Therm.	.....	Tube	....
1934	A-6	Con.	Recip.	2	D	⅛	SO_2	.....	.....	25 oz.	Ex. Va.	12 oz.	Therm.	.....	Tube	....
1935	B-1	Con.	Recip.	1	B	⅛	SO_2	.....	.....	24 oz.	Ex. Va.	16 oz.	Therm.	.....	Tube	....
1935	B-2	Con.	Recip.	2	B	⅛	SO_2	.....	.....	24 oz.	Ex. Va.	16 oz.	Therm.	.....	Tube	....

482. GENERAL ELECTRIC—GENERAL ELECTRIC CO., CLEVELAND, OHIO.

1927	....	Her.	Recip.*	1	D	...	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	Porc.	....
1928	....	Her.	Recip.*	1	D	...	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	Porc.	....
1929	....	Her.	Recip.*	1	D	...	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	Porc.	....
1930	....	Her.	Recip.*	1	D	...	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	Porc.	....
1931	....	Her.	Recip.*	1	D	...	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	Porc.	....
1932	....	Her.	Recip.*	1	D	...	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	Porc.	....
1933	....	Her.	Rtry.	...	D	...	M. For.	.....	.....	.....	H.S.F.	.....	Therm.	.....	S.S.	....
1933	....	S.H.	Rtry.	...	B	...	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	S.S.	....
1934	....	S.H.	Recip.*	1	D	...	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	S.S.	....
1935	CK-1	Her.	Recip.	1	D	...	SO_2	.....	.....	1.75#	H.S.F.	.....	Therm.	.....	S.S.	....
1935	CK-2	Her.	Recip.	1	D	...	SO_2	.....	.....	2.70#	H.S.F.	.....	Therm	.....	S.S.	....
1935	CK-30	Her.	Recip.	1	D	...	SO_2	.....	.....	2.70#	H.S.F.	.....	Therm.	.....	S.S.	....
1935	CB-3	Con.	Rtry.	...	B	...	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	S.S.	....

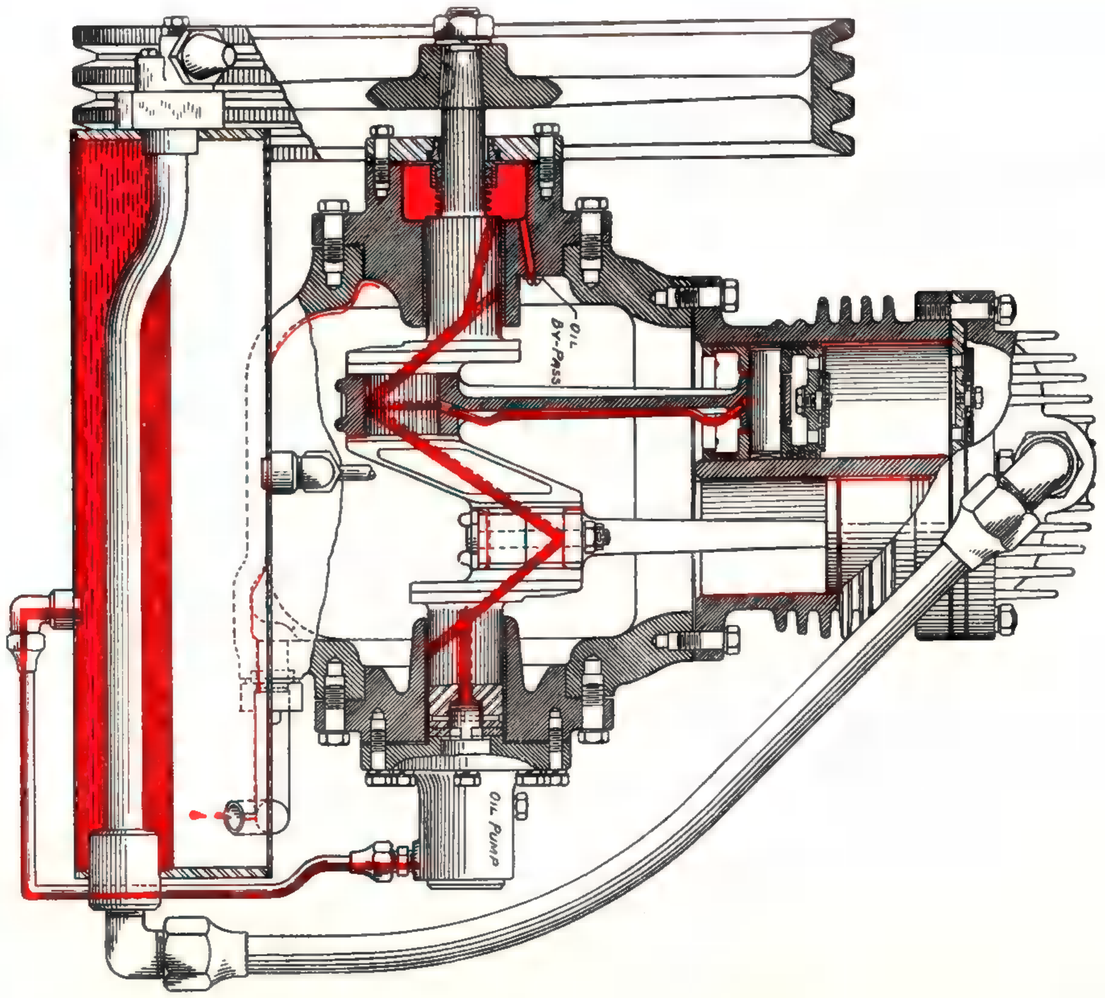


Fig. 342. Ice-O-Matic commercial compressor pressure lubricating system *(Courtesy of: Williams Oil-O-Matic Heating Corporation)*

483. GIBSON—GIBSON ELECTRIC REFRIGERATOR CORP., GREENVILLE, MICH.

1930	....	S.H.	Recip.	2	D	¼	SO_2	.....	.....	22 oz.	Ex. Va.	10 oz.	Therm.	.....	Tube	....
1931	....	S.H.	Recip.	2	D	¼	SO_2	.....	.....	22 oz.	Ex. Va.	10 oz.	Therm.	.....	Tube	....
1932	....	S.H.	Recip.	2	D	¼	SO_2	.....	.....	22 oz.	Ex. Va.	10 oz.	Therm.	.....	Tube	....
1933	GH	Her.	Recip.	2	D	⅛	SO_2	.....	.....	.....	H.S.F.	9 oz.	Therm.	.....	Porc.	....
1933	GOP	S.H	Recip.	2	D	⅛	SO_2	.....	.....	.....	H.S.F.	9 oz.	Therm.	.....	Porc.	....
1934	GH	Her.	Recip.	2	D	⅛	SO_2	.....	.....	.....	H.S.F.	9 oz.	Therm.	.....	Porc.	....
1934	GOP314	S.H.	Recip.	2	D	⅛	SO_2	.....	.....	.....	H.S.F.	9 oz.	Therm.	.....	Porc.	....
1935	H-5	Her.	Recip.	2	D	⅛	SO_2	.....	.....	.....	H.S.F.	14 oz.	Therm.	.....	Shelf	....
1935	GB-5	Con.	Recip.	2	B	⅛	SO_2	.....	.....	30 oz.	H.S.F.	11 oz.	Therm.	.....	Porc.	....

484. GILFILLAN—GILFILLAN BROS., INC., 1815 VENICE BLVD., LOS ANGELES

1935	5X	Con.	Recip.	2	B	⅛	SO_2	.....	7.5″	2#	Ex. Va.	12 oz.	Therm.	.....	Tube	....
	6X	Con.	Recip.	2	B	⅛	SO_2	.....	6.5″	2#	Ex. Va.	12 oz.	Therm.	.....	Tube	....
	7X	Con.	Recip.	2	B	⅛	SO_2	.....	4.5″	2#	Ex. Va.	12 oz.	Therm.	.....	Tube	....

485. GRUNOW—GENERAL HOUSEHOLD UTILITIES CO., CHICAGO, ILL.

1933	C	S.H.	Rtry	...	D	⅛	Car.	.....	.....	37 oz.	H.S.F.	26 oz.	Therm.	.....	Shell	....
1934	D	S.H.	Rtry.	...	D	⅛	Car	.....	.....	50 oz.	H.S.F.	36 oz.	Therm.	.....	Shell	....
1935	J	S.H.	Rtry.	...	D	⅛	Car	.....	.....	37 oz.	Cap. T.	36 oz.	Therm.	.....	Shell	....
	H	S.H.	Rtry.	...	D	⅛	Car	.....	.....	50 oz.	H.S.F.	36 oz.	Therm	.....	Shell	....
	K	S.H.	Rtry.	...	D	⅛	Car.	.....	.....	40 oz.	Cap. T.	36 oz.	Therm.	.....	Shell	....

486. HOLMES—HOLMES PRODUCTS INC., OBSOLETE, FORMERLY NEW YORK, N. Y.

....	....	S.H.	2 stage	...	D	⅛	Eth. Chl.	.....	.....	3½#	H.S.F.	2½ pt.	Therm.	.....	Flooded	....
....	....	S.H.	Rtry	...	D	⅛	Eth. Chl.	.....	.....	5½#	H.S.F.	2½ pt.	Therm.	.....	Flooded	....

487. ICE-O-MATIC—WILLIAMS OIL-O-MATIC HEATING CORP., BLOOMINGTON, ILL.

1932	A	Con.	Recip.	1	B	¼	M. C.	.....	.....	5.6#	L.S.F.	3 pt.	Therm.	.....	Plated	....
1932	AA Capital	Con.*	Recip.	1	D	⅛	M. C.	.....	.....	2.16#	L.S.F.	3 pt.	Therm.	.....	Plated	....
1932	X Capital	Con.*	Recip.	1	D	⅛	M. C.	.....	.....	2.16#	L.S.F.	3 pt.	Therm.	.....	Plated	....
1933	Y	Con.	Recip.	1	B	⅛	M. C.	.....	.....	2.3#	L.S.F.	1½ pt.	Therm.	.....	Plated	....
1934	Y	Con.	Recip.	1	B	⅛	M. C.	.....	.....	2.3#	L.S.F.	1½ pt.	Therm.	.....	Plated	....

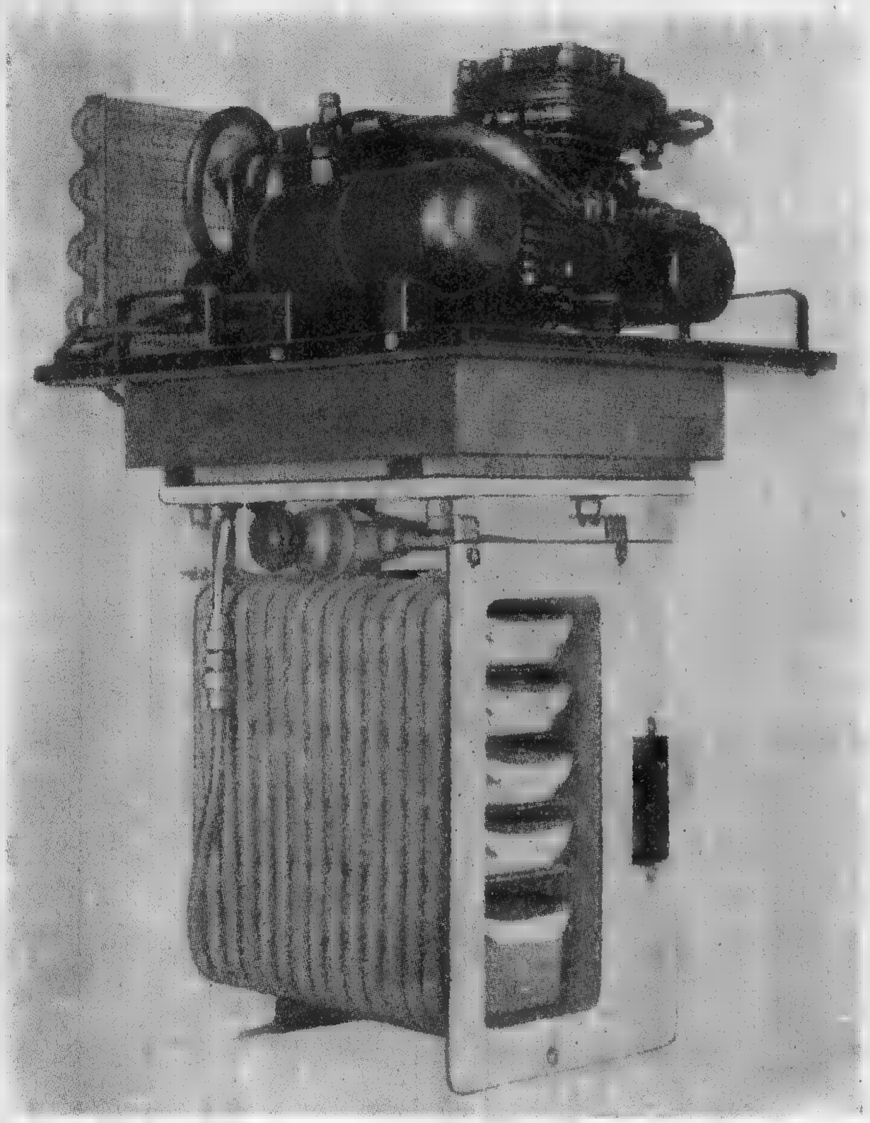


Fig. 339. The Fairbanks-Morse 1934 refrigerating unit
(Courtesy of: Fairbanks-Morse Corporation)

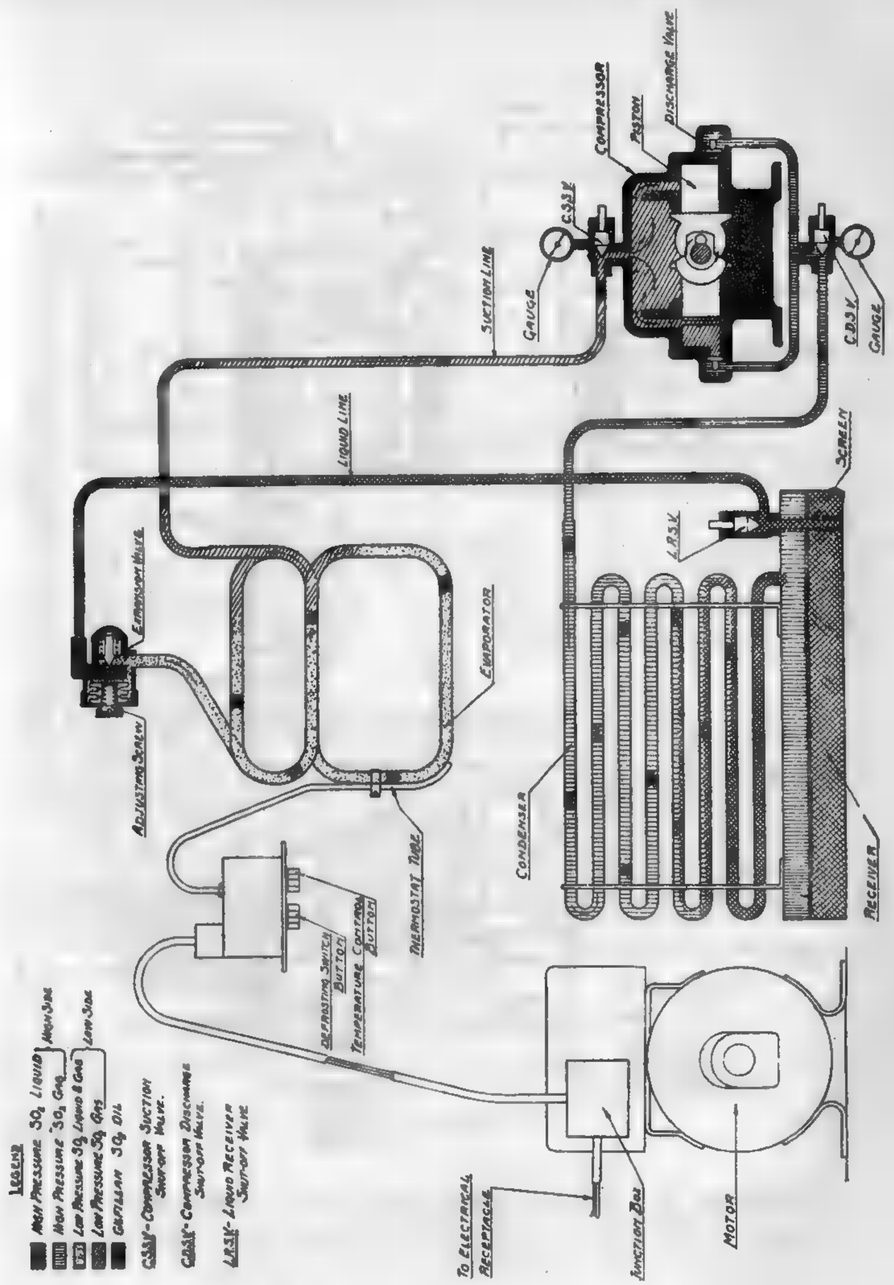


Fig. 340. The Gilfillan refrigeration cycle
(Courtesy of: The Gilfillan Bros. Company)

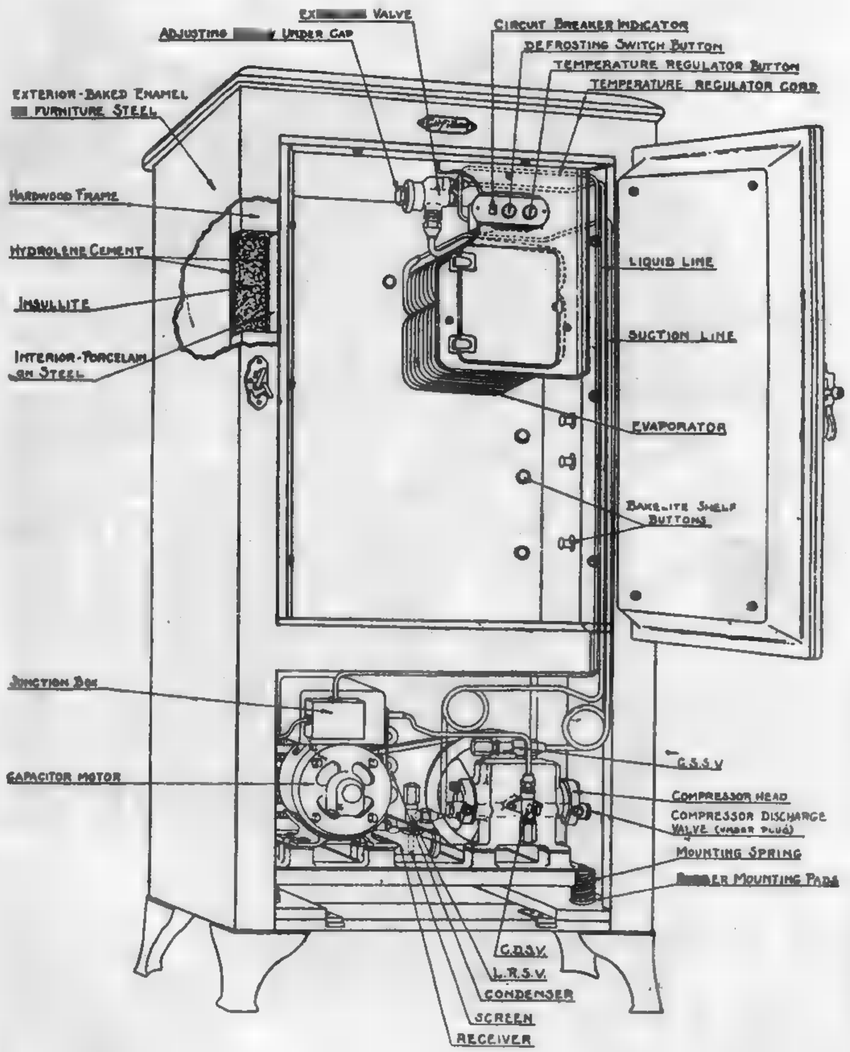


Fig. 341. The Gilfillan cabinet and unit assembly
(Courtesy of: The Gilfillan Bros. Company)

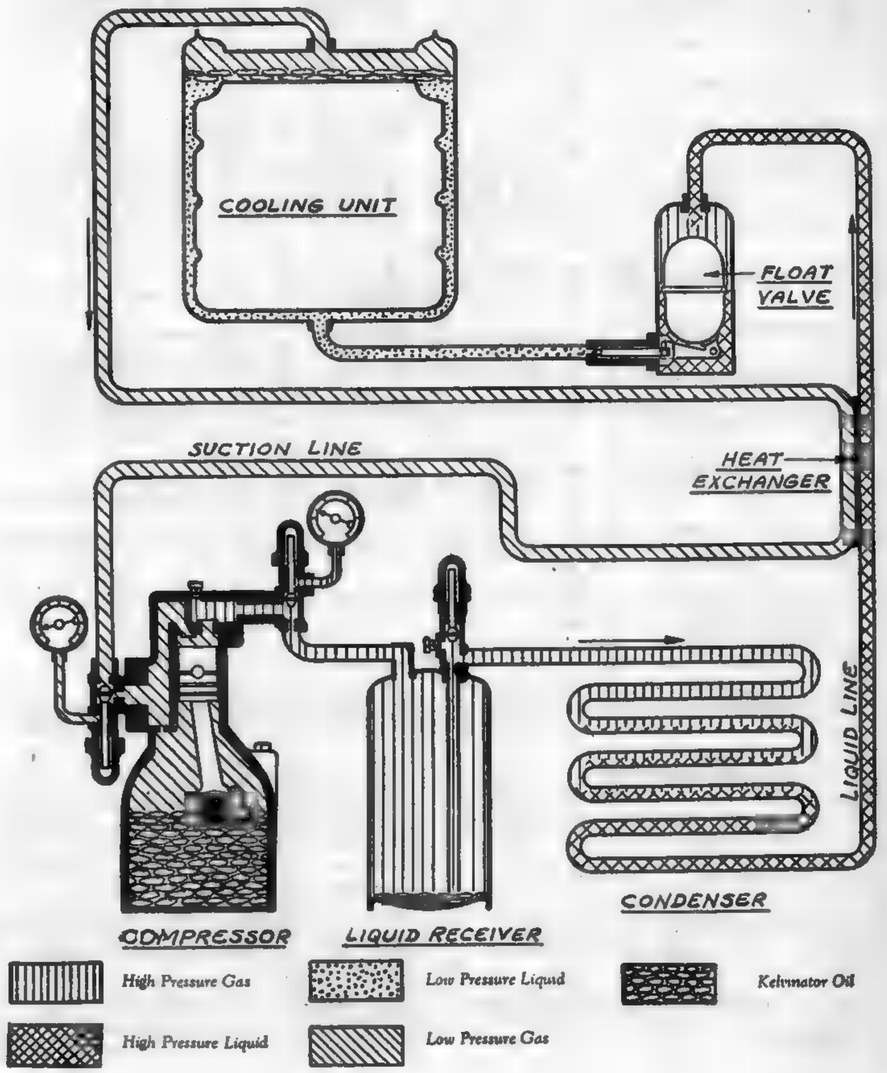


Fig. 342. The 1936 Kelvinator refrigerating cycle. Note the location of the liquid receiver. It is used for emergency and shipping storage only
(Courtesy of: Kelvinator Sales Corporation)

487. ICE-O-MATIC, Continued

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure	Quantity of Refrigerant	Refrigerant Control	Quantity of Oil	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
1935	TS	Con.	Recip.	1	B	1/8	M. C.	.....	.....	4.3#	L.S.F.	1½ pt.	Therm.	.....	Plated	....
1935	T	Con.	Recip.	2	B	1/6	M. C.	.....	.....	4.3#	L.S.F.	1½ pt.	Therm.	.....	Plated	....

488. INDIAN—INDIAN MOTORCYCLE COMPANY, SPRINGFIELD, MASS.

1928	5 cu. ft.	S.H.	Rtry.	...	D	1/6	SO_2	.....	.....	2#	Ex. Va.	1 pt.	Therm.	.....	Tube	....
	7 cu. ft.	S.H.	Rtry.	...	D	1/6	SO_2	.....	.....	2#	Ex. Va.	1 pt.	Therm.	.....	Tube	....

489. JOMOCO—JOHNSON MOTOR COMPANY, WAUKEGAN, ILL.

1934	R-10	Con.	Recip.	2	D	1/6	SO_2	.....	.....	24 oz.	Ex. Va.	12 oz.	Therm.	.....	Tube	....
1935	RU-3	Con.	Recip.	1	B	1/6	SO_2	.....	.....	24 oz.	Ex. Va.	16 oz.	Therm.	.....	Tube	....
1935	RU-4	.....	.....	2	B	1/6	SO_2	.....	.....	24 oz.	Ex. Va.	16 oz.	Therm.	.....	Tube	....

490. KELVINATOR—KELVINATOR CORPORATION, DETROIT, MICH.

1919 1920	D 1	Con.	Recip.	1	B	¼	SO_2	.....	.....	4	Ex. Va.	1¾	Therm.	.....	Brine	....
1921	D 2	Con.	Recip.	1	B	¼	SO_2	.....	.....	4	Ex. Va.	1¾	Therm.	.....	Brine	....
1922	J 1	Con.	Recip.	1	B	1/6	SO_2	.....	.....	3	Ex. Va.	1	Therm.	.....	Brine	....
	J 2	Con.	Recip.	1	B	1/6	SO_2	.....	.....	3	Ex. Va.	1	Therm.	.....	Brine	....
	J 3	Con.	Recip.	1	B	1/6	SO_2	.....	.....	3	Ex. Va.	1	Therm.	.....	Brine	....
	S 1	Con.	Recip.	2	B	¼	SO_2	.....	.....	4	Ex. Va.	1¾	Therm.	.....	Brine	....
	S 2	Con.	Recip.	2	B	¼	SO_2	.....	.....	4	Ex. Va.	1¾	Therm.	.....	Brine	....
	S 3	Con.	Recip.	2	B	¼	SO_2	.....	.....	4	Ex. Va.	1¾	Therm.	.....	Brine	....
1923	J 4	Con.	Recip.	1	B	1/6	SO_2	.....	.....	3	Ex. Va.	1	Therm.	.....	Brine	....
	S 4	Con.	Recip.	2	B	¼	SO_2	.....	.....	4	Ex. Va.	1¾	Therm.	.....	Brine	....
1924	J 5	Con.	Recip.	1	B	¼	SO_2	.....	.....	3	Ex. Va.	1	Therm.	.....	Brine	....
	J 6	Con.	Recip.	1	B	¼	SO_2	.....	.....	3	Ex. Va.	1	Therm.	.....	Brine	....
	S 5	Con.	Recip.	2	B	¼	SO_2	.....	.....	4	Ex. Va.	1¾	Therm.	.....	Brine	....
	S 6	Con.	Recip.	2	B	¼	SO_2	.....	.....	4	Ex. Va.	1¾	Therm.	.....	Brine	....
1925	J 7	Con.	Recip.	1	B	¼	SO_2	.....	.....	3	Ex. Va.	1	Therm.	.....	Brine	....
	J 8	Con.	Recip.	1	B	¼	SO_2	.....	.....	2½	Ex. Va.	1	Therm.	.....	Brine	....
	J 9	Con.	Recip.	1	B	¼	SO_2	.....	.....	2½	Ex. Va.	1	Therm.	.....	Brine	....
	S 7	Con.	Recip.	2	B	¼	SO_2	.....	.....	4	Ex. Va.	1¾	Therm.	.....	Brine	....
1926	J 7	Con.	Recip.	1	B	¼	SO_2	.....	.....	3	Ex. Va.	1	Therm.	.....	Brine	....
	J 11	Con.	Recip.	1	B	¼	SO_2	.....	.....	2½	Ex. Va.	1	Therm.	.....	Brine	....
	S 7	Con.	Recip.	2	B	¼	SO_2	.....	.....	3½	Ex. Va.	1¾	Therm.	.....	Brine	....
	S 11	Con.	Recip.	2	B	¼	SO_2	.....	.....	4	Ex. Va.	1¾	Therm.	.....	Brine	....
1927	J 7	Con.	Recip.	1	B	¼	SO_2	.....	.....	3	Ex. Va.	1	Therm.	.....	Brine	....
	J 11	Con.	Recip.	1	B	¼	SO_2	.....	.....	4	Ex. Va.	1¾	Therm.	.....	Brine	....
	S 7	Con.	Recip.	2	B	¼	SO_2	.....	.....	3	Ex. Va.	1¾	Therm.	.....	Brine	....
	S 11	Con.	Recip.	2	B	¼	SO_2	.....	.....	2	Ex. Va.	¾	Therm.	.....	Brine	....
	M	Con.	Recip.	1	B	1/6	SO_2	.....	.....	2	Ex. Va.	⅝	Therm.	.....	Brine	....
1928	J 12	Con.	Recip.	1	B	1/6	SO_2	.....	.....	2½	Ex. Va.	¾	Therm.	.....	Brine	....
	J 13	Con.	Recip.	1	B	1/6	SO_2	.....	.....	3	Ex. Va.	1¾	Therm.	.....	Brine	....
	S 12	Con.	Recip.	2	B	¼	SO_2	.....	.....	2	Ex. Va.	¾	Therm.	.....	Brine	....
1929	J 14	Con.	Recip.	1	B	1/6	SO_2	.....	.....	2	Ex. Va.	¾	Therm.	.....	Brine	....
	J 15	Con.	Recip.	1	B	1/6	SO_2	.....	.....	2	Ex. Va.	¾	Therm.	.....	Brine	....
	J 16	Con.	Recip.	1	B	1/6	SO_2	.....	.....	2	Ex. Va.	¾	Therm.	.....	Brine	....
	J 17	Con.	Recip.	1	B	1/6	SO_2	.....	.....	3	Ex. Va.	1½	Therm.	.....	Brine	....
	J 13	Con.	Recip.	2	B	¼	SO_2	.....	.....	2	Ex. Va.	¾	Therm.	.....	Brine	....
1930	J 16	Con.	Recip.	1	B	1/6	SO_2	.....	.....	2	Ex. Va.	¾	Therm.	.....	Brine	....
	J 17	Con	Recip.	1	B	1/6	SO_2	.....	.....	2	Ex. Va.	¾	Therm.	.....	Brine	....
1930	J 18	Con.	Recip.	1	B	1/6	SO_2	.....	.....	2	Ex. Va.	1½	Therm.	.....	Brine	....
	S 14	Con.	Recip.	2	B	¼	SO_2	.....	.....	2	Ex. Va.	1½	Therm.	.....	Brine	....
	CA 12	Con.	Recip.	1	B	1/10	SO_2	.....	.....	3½	L.S.F.	1½	Therm.	.....	Brine	....
	CB 20	Con.	Recip.	...	B	...	SO_2	.....	.....	2	Ex. Va.	¾	Therm.	.....	Brine	....
	A 11	Con.	Recip.	1	B	1/6	SO_2	.....	.....	3½	L.S.F.	1	Therm.	.....	Brine	....
	B 20	Con.	Recip.	...	B	...	SO_2	.....	.....	2	Ex. Va.	1½	Therm.	.....	Brine	....
1931	J 19	Con.	Recip.	...	B	1/6	SO_2	.....	.....	2	Ex. Va.	¾	Therm.	.....	Brine	....
1931	J 21	Con.	Recip.	1	B	1/6	SO_2	.....	.....	2	Ex. Va.	1½	Therm.	.....	Brine	....
	S 16	Con.	Recip.	2	B	¼	SO_2	.....	.....	3½	Ex. Va.	1½	Therm.	.....	Brine	....
	S 17	Con.	Recip.	2	B	1/3	SO_2	.....	.....	2	Ex. Va.	1	Therm.	.....	Brine	....
	CA 10	Con.	Recip.	1	B	1/6	SO_2	.....	.....	3¼	L.S.F.	1½	Therm.	.....	Brine	....

490. KELVINATOR, Continued

Year	Model	Box Code	Condensing Unit Code	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure	Quantity of Refrigerant	Refrigerant Control	Quantity of Oil	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
1931	CA 12			Con.	Recip.	1	B	1/10	SO_2	.....	.....	.....	Ex. Va.	1	Therm.	.....	Brine	....
	CB 22			Con.	Recip.	1	B	1/6	SO_2	.....	.....	3¼	L.S.F.	1¾	Therm.	.....	Brine	....
	CB 23			Con.	Recip.	2	B	¼	SO_2	.....	.....	2	Ex. Va.	1½	Therm.	.....	Brine	....
1932	CA150			Con.	Recip.	.1	B	⅙	SO_2	.....	.....	3½	L.S.F.	1½	Therm.	.....	Brine	....
	CB150			Con.	Recip.	1	B	¼	SO_2	.....	.....	2	Ex. Va.	1⅝	Therm.	.....	Brine	....
	CB532			Con.	Recip.	1	B	⅙	SO_2	.....	.....	2	L.S.F.	1⅝	Therm.	.....	Flooded	....
	FB510			Con.	Recip.	2	B	⅛	SO_2	.....	.....	3½	L.S.F.	2¼	Therm.	.....	Brine	....
	FB511			Con.	Recip.	2	B	⅛	SO_2	.....	.....	3½	L.S.F.	2¼	Therm.	.....	Brine	....
	A532			Con.	Recip.	1	B	1/10	SO_2	.....	.....	3½	L.S.F.	1¼	Therm.	.....	Flooded	....
1933	CA530			Con.	Recip.	1	B	1/10	SO_2	.....	.....	3½	H.S.F.	.....	Therm.	.....	Flooded	....
	CA550			Con.	Recip.	1	B	⅙	SO_2	.....	.....	3½	H.S.F.	1¼	Therm.	.....	Flooded	....
	CB510			Con.	Recip.	2	B	⅙	SO_2	.....	.....	2	H.S.F.	1⅝	Therm.	.....	Flooded	....
	CB530			Con.	Recip.	2	B	⅙	SO_2	.....	.....	3	H.S.F.	.....	Therm.	.....	Flooded	....
	CB531			Con.	Recip.	2	B	¼	SO_2	.....	.....	2	Ex. Va.	1⅝	Therm.	.....	Brine	....
	CB531			Con.	Recip.	2	B	¼	SO_2	.....	.....	3	H.S.F.	.....	Therm.	.....	Brine	....
1933	CB551			Con.	Recip.	2	B	⅛	SO_2	.....	.....	1.625	Ex. Va.	1⅝	Therm.	.....	Brine	....
1933	FB512			Con.	Recip.	2	B	⅛	SO_2	.....	.....	2	Ex. Va.	2¼	Therm.	.....	Brine	....
1934		N	A9116A	Con.	Recip.	1	B	⅙	SO_2	.....	6″	2# 13 oz. 2# 9 oz.	H.S.F.	1# 3 oz.	Therm.	E1 E2	Flooded	....
		NA	A9116A	Con.	Recip.	1	B	⅙	SO_2	.....	6″	3# 2 oz. 2# 14 oz.	H.S.F.	1# 3 oz.	Therm.	E1 E2	Flooded	....
		NAS	B9116A	Con.	Recip.	2	B	⅙	SO_2	.....	6″	2# 15 oz. 2# 11 oz.	H.S.F.	1# 10 oz.	Therm.	E1 E2	Flooded	....
		NB	B9116A	Con.	Recip.	2	B	⅙	SO_2	.....	6″	2# 15 oz. 2# 11 oz.	H.S.F.	1# 10 oz.	Therm.	E1 E2	Flooded	....
		NBS	B9125A	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 15 oz. 2# 11 oz.	H.S.F.	1# 10 oz.	Therm.	E1 E2	Flooded	....
		V	B9125A	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 13 oz. 2# 9 oz.	H.S.F.	1# 10 oz.	Therm.	E1 E2	Flooded	....
		AS	B9125A	Con.	Recip.	2	B	¼	SO_2	.....	6″	3# 2 oz. 2# 14 oz.	H.S.F.	1# 10 oz.	Therm.	E1 E2	Flooded	....
		ASS	B9133A	Con.	Recip.	2	B	⅓	SO_2	.....	6″	2# 15 oz. 2# 11 oz.	H.S.F.	1# 10 oz.	Therm.	E1 E2	Flooded	....
		CKN	B9133A	Con.	Recip.	2	B	⅓	SO_2	.....	8″	12 oz. 1# 4 oz.	H.S.F.	1# 10 oz.	Therm.	1 series 2 series	Flooded	....
		D2	B9133A	Con.	Recip.	2	B	⅓	SO_2	.....	4″	1# 5 oz. 1# 1 oz.	H.S.F.	1# 10 oz.	Therm.	E1 E2	Brine	....
		D4	G9133A	Con.	Recip.	2	B	⅓	SO_2	.....	4″	1# 7 oz. 1# 3 oz.	H.S.F.	2#	Therm.	E1 E2	Brine	....
		D6	G9133A	Con.	Recip.	2	B	⅓	SO_2	.....	4″	1# 11 oz. 1# 7 oz.	H.S.F.	2#	Therm.	E1 E2	Brine	....
		SA	A9116A	Con.	Recip.	1	B	⅙	SO_2	.....	6″	3# 2 oz. 2# 14 oz.	H.S.F.	1# 3 oz.	Therm.	E1 E2	Brine	....
		SAS	B9116A	Con.	Recip.	2	B	⅙	SO_2	.....	6″	2# 15 oz. 2# 11 oz.	H.S.F	1# 10 oz.	Therm.	E1 E2	Flooded	....
		SB	B9116A	Con.	Recip.	2	B	⅙	SO_2	.....	6″	3# 2 oz. 2# 14 oz.	H.S.F.	1# 10 oz.	Therm.	E1 E2	Flooded	....
		SBS	B9125A	Con.	Recip.	2	B	¼	SO_2	.....	6″	3# 2 oz. 2# 14 oz.	H.S.F.	1# 10 oz.	Therm.	E1 E2	Flooded	....
		SC	B9125A	Con.	Recip.	2	B	¼	SO_2	.....	6″	3# 2 oz. 3# 14 oz.	H.S.F.	1# 10 oz.	Therm.	....	Flooded	....
1935		KY275	A9116AC	Con.	Recip.	1	B	⅙	SO_2	.....	6″	2# 6 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
		K300	A9116AC	Con.	Recip.	1	B	⅙	SO_2	.....	6″	1# 9 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
		K4254	A9116AC	Con.	Recip.	1	B	⅙	SO_2	.....	6″	2# 6 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
		K425S	B9116AC	Con.	Recip.	2	B	⅙	SO_2	.....	6″	2# 3 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
		K485	A9116AC	Con.	Recip.	1	B	⅙	SO_2	.....	6″	2# 12 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
1935		K4855	B9116AC	Con.	Recip.	2	B	⅙	SO_2	.....	6″	2# 9 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
		K 541	A9116AC	Con.	Recip.	1	B	⅙	SO_2	.....	6″	2# 9 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
		K5415	B9116AC	Con.	Recip.	2	B	⅙	SO_2	.....	6″	2# 3 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
		K 650	B9116AC	Con.	Recip.	2	B	⅙	SO_2	.....	6″	2# 3 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....

490. KELVINATOR, Continued

Year	Box Code	Condensing Unit Code	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure	Quantity of Refrigerant	Refrigerant Control	Quantity of Oil	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
1935	K650S	B9125AS	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 3 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	K760	B9125AE	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 8 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	SD658	B9125AE	Con.	Recip.	2	B	¼	SO_2	.....	4″	1# 1 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Brine	....
	SD782	B9125AE	Con.	Recip.	2	B	¼	SO_2	.....	4″	1# 1 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Brine	....
	SD903	B9133AB	Con.	Recip.	2	B	⅛	SO_2	.....	4″	1# 1 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Brine	....
	SD1268	B9133AB	Con.	Recip.	2	B	⅛	SO_2	.....	4″	1# 3 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Brine	....
	SD1525	G9133A	Con.	Recip.	2	B	⅛	SO_2	.....	4″	1# 7 oz.	H.S.F.	2#	Therm.	.....	Brine	....
	SD2332	G9133A	Con.	Recip.	2	B	⅛	SO_2	.....	4″	1# 7 oz.	H.S.F.	2#	Therm.	.....	Brine	....
	P425	A9116AC	Con.	Recip.	1	B	⅙	SO_2	.....	6″	2# 12 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	P4255	B9116AC	Con.	Recip.	2	B	⅙	SO_2	.....	6″	2# 9 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	P541	A9116AC	Con.	Recip.	1	B	⅙	SO_2	.....	6″	2# 9 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	P5415	B9116AC	Con.	Recip.	2	B	⅙	SO_2	.....	6″	2# 3 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	P650	B9116AC	Con.	Recip.	2	B	⅙	SO_2	.....	6″	2# 3 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	P6505	B9125AE	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 3 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	P760	B9125AE	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 8 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	P513	A9116AC	Con.	Recip.	1	B	⅙	SO_2	.....	6″	2# 14 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	P5135	B9125AE	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 14 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	P617	B9116AC	Con.	Recip.	2	B	⅙	SO_2	.....	6″	3#	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
1935	D617S	B9125AE	Con.	Recip.	2	B	¼	SO_2	.....	6″	3#	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
1935	D736	B9125AE	Con.	Recip.	2	B	¼	SO_2	.....	6″	3#	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
1935	D873	B9125AE	Con.	Recip.	2	B	¼	SO_2	.....	6″	3#	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
1936	.....	A9116D	Con.	Recip.	1	B	⅙	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	Flooded	....
1936	.....	B9116D	Con.	Recip.	2	B	⅙	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	Flooded	....
1936	.....	B9116E	Con.	Recip.	2	B	⅙	SO_2	.....	.....	.....	H.S.F.	1# 8 oz.	Therm.	.....	Flooded	....
1936	.....	B9125G	Con.	Recip.	2	B	¼	SO_2	.....	.....	.....	H.S.F.	1# 8 oz.	Therm.	.....	Flooded	....
1936	.....	B9125H	Con.	Recip.	2	B	¼	SO_2	.....	.....	.....	H.S.F.	1# 8 oz.	Therm.	.....	Flooded	....

491. LECTRIC-ICE—UNIFLOW MANUFACTURING CO., ERIE, PA.

Year	Model																
1934	DM5	Con.	Recip.	1	B	⅛	M. C.	.....	.....	1½#	Ex. Va.	8 oz.	Therm.	.....	Tube	....
	DM6	.....	.....	1	B	¼	M. C.	.....	.....	1½#	Ex. Va.	24 oz.	Therm.	.....	Tube	....
	DM7	.....	.....	1	B	¼	M. C	.....	.....	1¾#	Ex. Va.	24 oz.	Therm.	.....	Tube	....
	DM8	.....	.....	1	B	¼	M. C.	.....	.....	1¾#	Ex. Va.	24 oz.	Therm.	.....	Tube	....
	M15	.....	.....	2	B	⅛	M. C.	.....	.....	2#	Ex. Va.	36 oz.	Therm.	.....	Tube	....
1935	M20	Con.	Recip.	2	B	⅛	M. C.	.....	.....	2½#	Ex. Va.	36 oz.	Therm.	.....	Tube	....
1935	Commercial	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1935	D-475A	Con.	Recip.	2	B	⅛	M. C.	.....	.....	3#	*	36 oz.	■	.....	*	....
	D-525A	.....	.....	2	B	½	.....	.....	.....	3#	.....	36 oz	.....	.....	.....	....
	E-375A	.....	.....	4	B	¾	.....	.....	.....	3½#	.....	70 oz.	.....	.....	.....	....
	E-475A	.....	.....	4	B	1	.....	.....	.....	4#	.....	70 oz	.....	.....	.....	....
	F-375A	.....	.....	4	B	1½	.....	.....	.....	6#	.....	70 oz.	.....	.....	.....	....
	F-475A	.....	.....	4	B	2	.....	.....	.....	7#	.....	70 oz.	.....	.....	.....	....
	G-475W	.....	.....	2	B	3	.....	.....	.....	10#	.....	70 oz.	.....	.....	.....	....

492. LEONARD—LEONARD REFRIGERATOR CORP., DETROIT, MICH.

Year	Box Code	Condensing Unit Code														
1931	L5	A12	Con.	Recip.	1	B	1/10	SO_2	.....	10″	2# 14 oz.	L.S.F.	1#	Therm.	.....	Flooded	3 oz.
	L55	B22	Con.	Recip.	1	B	⅕	SO_2	.....	10″	3# 4 oz.	L.S.F.	1# 8 oz.	Therm.	.....	Flooded	9 oz.
	L7	A10	Con.	Recip.	1	B	⅙	SO_2	.....	10″	3# 4 oz.	L.S.F.	1#	Therm.	.....	Flooded	9 oz.
	L75	B22	Con.	Recip.	1	B	⅕	SO_2	.....	10″	3# 4 oz.	L.S.F.	1# 8 oz.	Therm.	.....	Flooded	9 oz.
1932	.....	A530	Con.	Recip.	1	B	1/10	SO_2	.....	6″	3# 5 oz.	L.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	.....	B530	Con.	Recip.	1	B	⅛	SO_2	.....	6″	3# 5 oz.	L.S.F.	1# 18 oz.	Therm.	.....	Flooded	....
	.....	A550	Con.	Recip.	1	B	⅙	SO_2	.....	6″	3#	L.S.F	1# 3 oz.	Therm.	.....	Flooded	....
1933	.....	A530	Con	Recip.	1	B	1/10	SO_2	.....	6″	3# 5 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	.....	A550	Con.	Recip.	1	B	⅙	SO_2	.....	6″	3#	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	.....	B531	Con.	Recip.	2	B	¼	SO_2	.....	6″	3# 10 oz.	H.S.F.	1# 2 oz.	Therm.	.....	Flooded	....
	.....	B510	Con.	Recip.	1	B	⅙	SO_2	.....	6″	3# 10 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	.....	B551	Con.	Recip.	1	B	¼	SO_2	.....	6″	3# 14 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
1934	.....	A9112	Con.	Recip.	1	B	⅛	SO_2	.....	8″	1# 12 oz. 14 oz.	H.S.F.	14 oz.	Therm	.....	Flooded	....

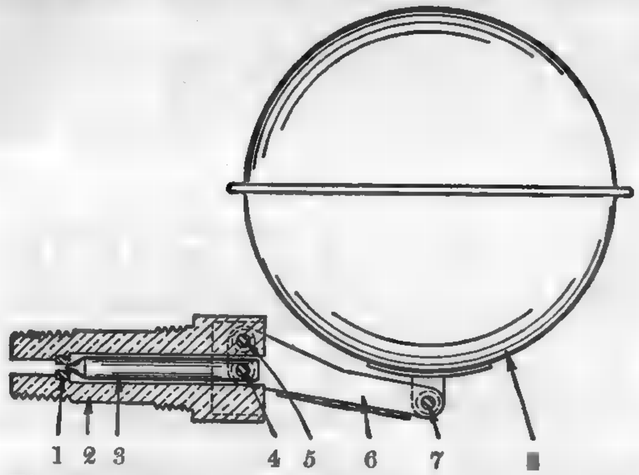


Fig. 343. The Leonard high side float mechanism
1. Valve seat; 2. Valve cage; 3. Valve; 4. Valve pin; 5. Arm pin; 6. Arm; 7. Float pin; 8. Float
(Courtesy of: Leonard Sales Corporation)

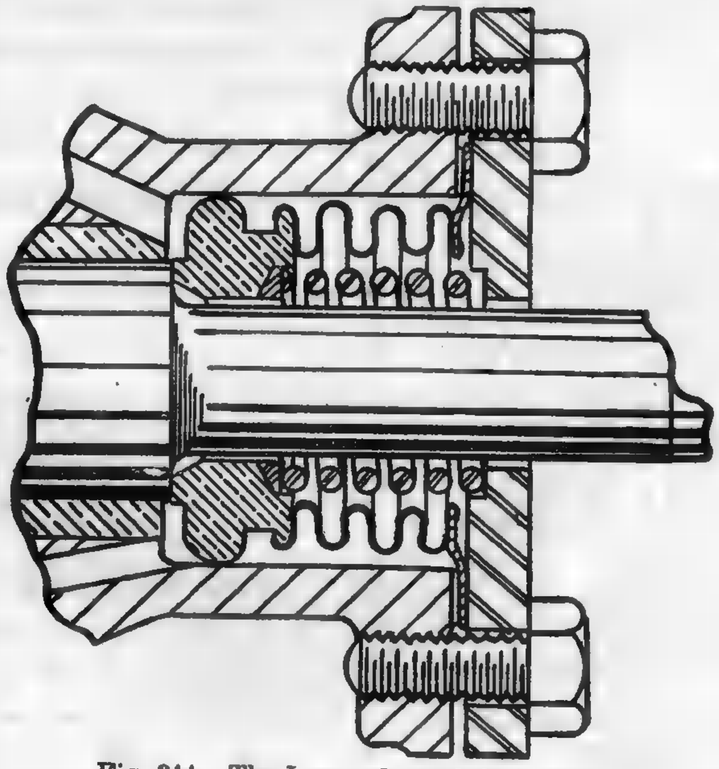
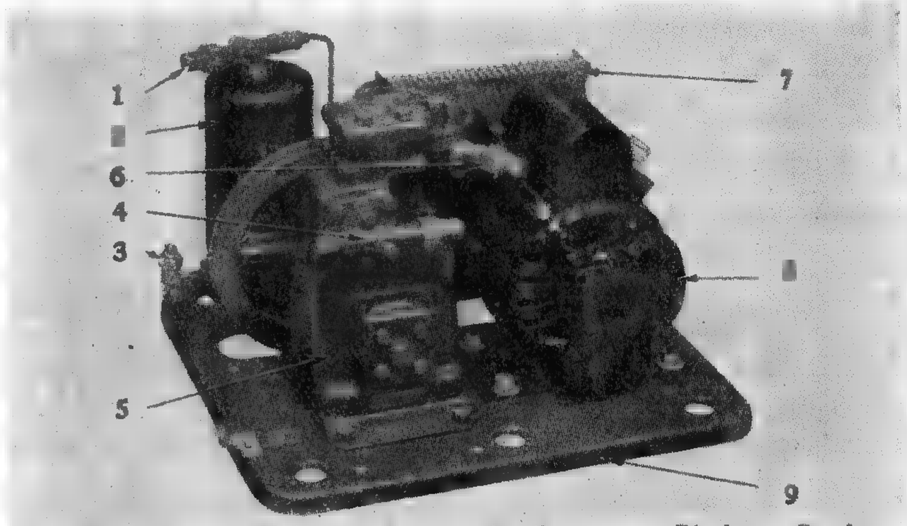


Fig. 344. The Leonard crankshaft seal
(Courtesy of: Leonard Sales Corporation,



1. Purging Service Valve.
2. Liquid Receiver.
3. Liquid Receiver Service Valve.
4. Compressor Suction Service Valve.
5. Compressor.
6. Compressor Discharge Service Valve.
7. Condenser.
8. Motor.
9. Condensing Unit Base.

Fig. 345. The 1935 Leonard condensing unit
(Courtesy of: Leonard Sales Corporation)

492. LEONARD, Continued

Year	Box Code	Condensing Unit Code	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure	Quantity of Refrigerant	Refrigerant Control	Quantity of Oil	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
1934	LX5	A9116A	Con.	Recip.	1	B	⅛	SO_2	.....	6″	2# 13 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	LX55	A9116A	Con.	Recip.	1	B	⅛	SO_2	.....	6″	2# 9 oz. 3# 2 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	SL1	B9116A	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 14 oz. 2# 15 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	SL15	A9116A	Con.	Recip.	1	B	⅛	SO_2	.....	6″	2# 11 oz. 2# 13 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	SL155	A9116A	Con.	Recip.	1	B	⅛	SO_2	.....	6″	2# 9 oz. 3# 2 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	SL2	B9116A	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 14 oz. 2# 15 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	SL25	A9116B	Con.	Recip.	1	B	⅛	SO_2	.....	6″	2# 11 oz. 3# 2 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	SL3	B9116B	Con.	Recip.	2	B	⅛	SO_2	.....	6″	2# 14 oz. 2# 15 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	SL35	B9116B	Con.	Recip.	2	B	⅛	SO_2	.....	6″	2# 11 oz. 3# 2 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	SP2	B9125A	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 14 oz. 3# 2 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	SP25	A9116B	Con.	Recip.	1	B	⅛	SO_2	.....	6″	2# 14 oz. 3# 2 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	6D2	B9125A	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 14 oz. 2# 15 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	LD25	B9116B	Con.	Recip.	2	B	⅛	SO_2	.....	6″	2# 11 oz. 3# 2 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
											2# 14 oz.						
	LD3	B9125A	Con.	Recip.	2	B	¼	SO_2	.....	6″	3# 2 oz. 2# 14 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	LD35	B9116B	Con.	Recip.	2	B	⅛	SO_2	.....	6″	3# 2 oz. 2# 14 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	...
	PD2	B9125A	Con.	Recip.	2	B	¼	SO_2	.....	6″	3# 2 oz. 2# 14 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	PD25	B9116B	Con.	Recip.	2	B	⅛	SO_2	.....	6″	3# 2 oz. 2# 14 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	PD3	B9125A	Con.	Recip.	2	B	¼	SO_2	.....	6″	3# 2 oz. 2# 14 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	PD35	B9116B	Con.	Recip.	2	B	⅛	SO_2	.....	6″	3# 7 oz. 3# 3 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	PD4	B9125A	Con.	Recip.	2	B	¼	SO_2	.....	6″	3# 7 oz. 3# 3 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	.....	B9125A	Con.	Recip.	2	B	¼	SO_2	.....	6″	3# 7 oz. 3# 3 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	.....	B9125B	Con.	Recip.	2	B	⅛	SO_2	.....	6″	3# 10 oz. 3# 6 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
1935	LX275	A9116A	Con.	Recip.	1	B	⅛	SO_2	.....	6″	2# 6 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	L330	A9116A	Con.	Recip.	1	B	⅛	SO_2	.....	6″	1# 9 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	LA	A9116A	Con.	Recip.	1	B	⅛	SO_2	.....	6″	2# 6 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	LAS	B9116A	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 2 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	SL435	A9116A	Con.	Recip.	1	B	⅛	SO_2	.....	6″	2# 6 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	SL4335	B9116A	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 2 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	SL525	A9116A	Con.	Recip.	1	B	⅛	SO_2	.....	6″	2# 12 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	SL5255	B9116A	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 9 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	SL600	B9116A	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 14 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	SL6005	B9125AF	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 14 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	SL721	B9116A	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 14 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	SL7215	B9125AF	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 14 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	SP525	A9116A	Con.	Recip.	1	B	⅛	SO_2	.....	6″	2# 12 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	SP5255	B9116A	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 9 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	SP600	B9116A	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 14 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	SP6005	B9125AF	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 14 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	LD553	A9116A	Con.	Recip.	1	B	⅛	SO_2	.....	6″	2# 12 oz.	H.S.F.	1# 3 oz.	Therm.	.....	Flooded	....
	LD5335	B9116A	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 9 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	PD558	B9116A	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 14 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....

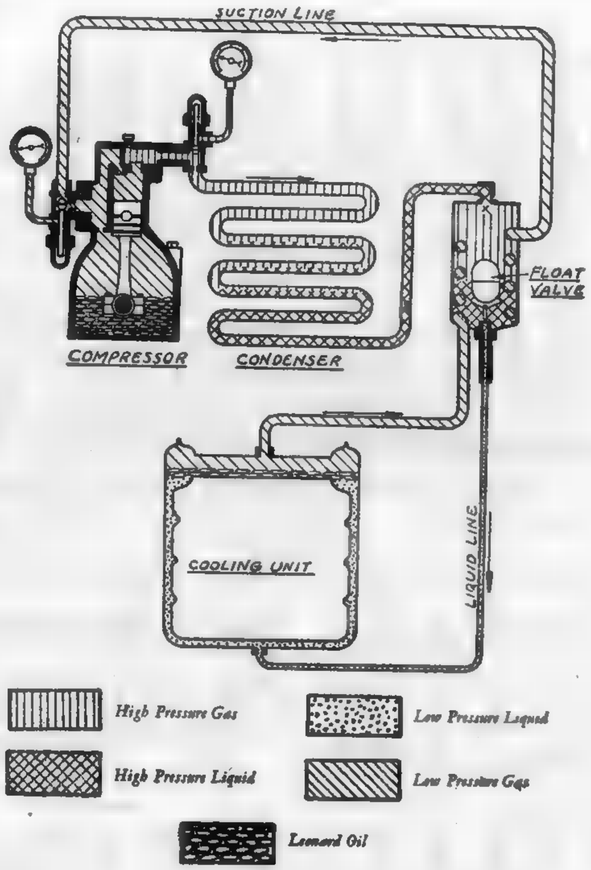


Fig. 345A. The 1936 Leonard refrigerating cycle. Note the heat exchanger built into the high side float chamber
(Courtesy of: Leonard Sales Corporation)

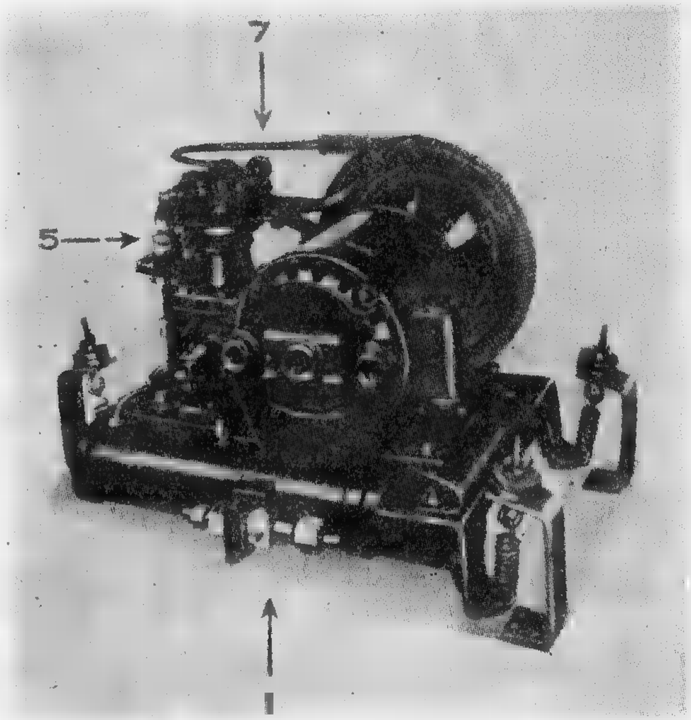


Fig. 346. The Merchant and Evans 1935 condensing unit 1. L.R.S.V.; 5. S.S.V.; 7. D.S.V.
(Courtesy of: Merchant & Evans Company)

492. LEONARD, Continued

Year	Box Code	Condensing Unit Code	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure	Quantity of Refrigerant	Refrigerant Control	Quantity of Oil	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
1935	PD5885	B9125AF	Con.	Recip.	2	B	¼	SO_2	.....	6″	2# 14 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	PD704	B9116A	Con.	Recip.	2	B	¼	SO_2	.....	6″	3#	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	PD7045	B9125AF	Con.	Recip.	2	B	¼	SO_2	.....	6″	3#	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	PD896	B9125AF	Con.	Recip.	2	B	¼	SO_2	.....	6″	3#	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
	PD1057	B9125BG	Con.	Recip.	2	B	¼	SO_2	.....	6″	3# 4 oz.	H.S.F.	1# 10 oz.	Therm.	.....	Flooded	....
1936	.....	.....	Con.	Recip.	1	D	...	F-12	.....	.....	.....	.....	.....	Therm.	.....	Flooded	....
	Model																
1936	LS5-36		Con.	Recip.	1	D	⅛	Freon	.....	.....	1# 11 oz.	H.S.F.	15 oz.	Therm.	.....	Flooded	....
1936	LS6-36		Con.	Recip.	1	D	⅛	.....	.....	.....	1# 12 oz.	H.S.F.	15 oz.	Therm.	.....	Flooded	....
1936	L3-36		Con.	Recip.	1	D	⅛	.....	.....	.....	1# 6 oz.	H.S.F.	15 oz.	Therm.	.....	Flooded	....
1936	L4-36		Con.	Recip.	1	D	⅛	.....	.....	.....	1# 10 oz.	H.S.F.	15 oz.	Therm.	.....	Flooded	....
1936	L7-36		Con.	Recip.	1	D	⅙	.....	.....	.....	1# 14 oz.	H.S.F.	15 oz.	Therm.	.....	Flooded	....
1936	P10-36		Con.	Recip.	1	D	¼	.....	.....	.....	3#	H.S.F.	15 oz.	Therm.	.....	Flooded	....

493. MAJESTIC—GRIGSBY-GRUNOW CO., CHICAGO, ILL.

	50	Con	Rtry.	...	B	⅛	SO_2	.....	.....	4#	L.S.F.	26 oz.	Therm.	.....	Flooded	....
	51	Con.	Rtry.	...	B	⅛	SO_2	.....	.....	4#	L.S.F.	26 oz.	Therm.	.....	Flooded	....
	101	Her.	Rtry.	...	D	⅙	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	Porc.	....
	102	Her.	Rtry.	...	D	⅙	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	Porc.	....
	103	Her.	Rtry.	...	D	⅙	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	Porc.	....
	205	Her.	Rtry.	...	D	⅙	SO_2	.....	.....	.....	H.S.F	.....	Therm.	.....	Porc.	....
	207	Her.	Rtry.	...	D	⅙	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	Porc.	....
	209	Her.	Rtry.	...	D	⅙	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	Porc.	....
	103-2	Her.	Rtry.	...	D	⅙	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	Porc.	....
	103-3	Her.	Rtry.	...	D	⅙	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	Porc.	....

494. MAYFLOWER—TRUPAR MFG. CO., DETROIT, MICH.

1932	70	Con.	Recip.	1	B	⅙	SO_2	.....	.....	1½#	L.S.F.	¾ pt.	Therm	.....	Porc.	....
1933	140	Con.	Recip.	1	B	¼	SO_2	.....	.....	2#	L.S.F.	1 pt.	Therm	.....	Porc.	....
1934	....	Con.	Recip.	1	B	⅙	SO_2	.....	.....	1½#	L.S.F.	1 pt.	Therm.	.....	Porc.	....
1935	A-1	Con.	Recip.	1	B	⅙	M. C.	.....	.....	1¼#	Ex. Va.	¾ pt.	Therm.	.....	Porc.	....

495. MERCHANT & EVANS—MERCHANT & EVANS CO., 2035 WASHINGTON AVE., PHILADELPHIA, PA.

1934	70DS	Con	Recip.	1	B	⅙	SO_2	.....	.....	1¼#	L.S.F.	5½ oz.	Therm.	.....	Plated	....
1934	70DMC	Con.	Recip.	1	B	⅙	M. C	.....	.....	1#	Ex. Va.	5½ oz.	Therm.	.....	Plated	....
1934 and 1935	100D	Con.	Recip	1	B	⅙	SO_2	.....	.....	2#	L.S.F.	8 oz.	Therm.	.....	Plated	....
1934 and 1935	120MC	Con.	Recip.	1	B	⅙	M. C.	.....	.....	1½#	Ex. Va.	8 oz.	Therm	.....	Plated	....

496. NORGE—NORGE CORPORATION, DETROIT, MICH.

1930	4 and 5	Con.	Rtry.	...	B	⅕	SO_2	14	.....	2#	L.S.F.	28 oz.	Therm.	.....	Flooded	....
	5AP2	Con.	Rtry.	...	B	⅕	SO_2	14	.....	2¼#	L.S.F.	28 oz.	Therm.	.....	Flooded	....
	7	Con.	Rtry.	...	B	¼	SO_2	14	.....	3½#	L.S.F.	28 oz.	Therm.	.....	Flooded	....
1931	51	Con.	Rtry.	...	B	⅕	SO_2	19	.....	3½#	L.S.F.	28 oz.	Therm.	.....	Flooded	....
	51P	Con.	Rtry.	...	B	⅕	SO_2	19	.....	3½#	L.S.F.	28 oz.	Therm.	.....	Flooded	....
	51S	Con.	Rtry.	...	B	⅕dc	SO_2	19	.....	3½#	L.S.F.	28 oz.	Therm.	.....	Flooded	....
	61	Con.	Rtry.	...	B	⅙	SO_2	19	.....	4#	L.S.F.	28 oz.	Therm.	.....	Flooded	....
	61P	Con.	Rtry.	...	B	⅙	SO_2	19	.....	4#	L.S.F.	28 oz.	Therm.	.....	Flooded	....
	71	Con.	Rtry.	...	B	⅙	SO_2	19	.....	4#	L.S.F.	28 oz.	Therm.	.....	Flooded	....
1932	A	Con.	Rtry.	...	B	⅙	SO_2	13	.....	4#	L.S.F.	28 oz.	Therm.	.....	Flooded	....
	B	Con.	Rtry.	...	B	⅕	SO_2	13	.....	5#	L.S.F.	28 oz.	Therm.	.....	Flooded	....
	BP	Con.	Rtry.	...	B	⅕	SO_2	13	.....	5#	L.S.F.	28 oz.	Therm.	.....	Flooded	....
	BPF	Con.	Rtry.	...	B	⅕	SO_2	13	.....	5¾#	L.S.F.	28 oz.	Therm.	.....	Flooded	....
	H	Con.	Rtry.	...	B	¼	SO_2	6	.....	3#	Ex. Va.	28 oz.	Therm.	.....	Tube	....
1933	A44	Con.	Rtry.	...	B	⅙	SO_2	9	.....	5#	L.S.F.	32-33 oz.	Therm	.....	Flooded	....

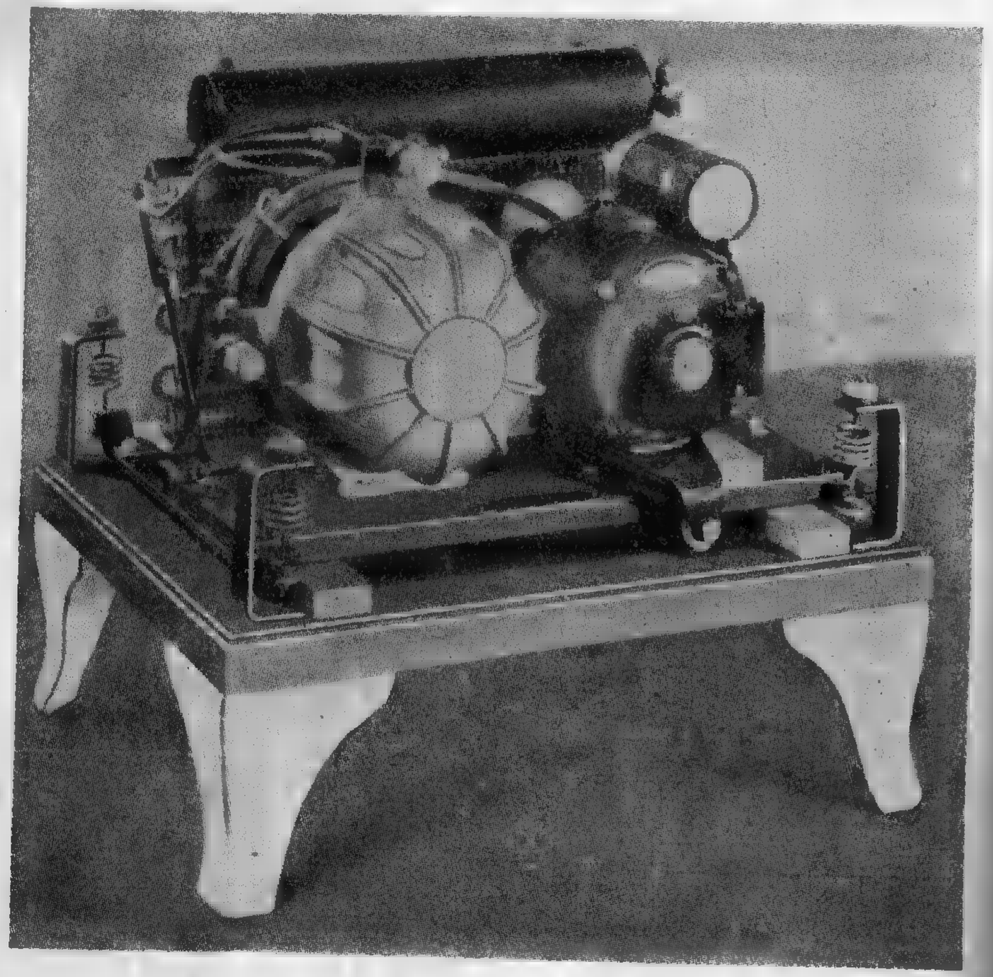


Fig. 847. The Norge 1935 condensing unit
(Courtesy of: Norge Corporation)

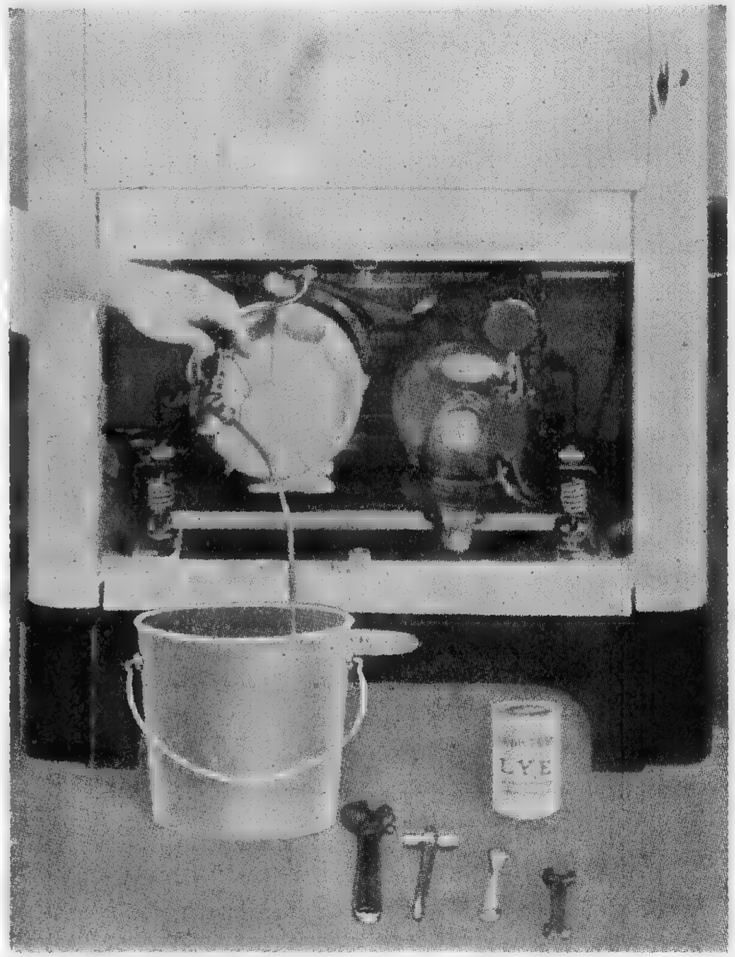


Fig. 848. Discharging the Norge compressor. Note the hand valve used to control the rapidity of flow of the refrigerant into the lye bucket
(Courtesy of: Norge Corporation)

496. NORGE, Continued

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure	Quantity of Refrigerant	Refrigerant Control	Quantity of Oil	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
1933	AP-44	Con.	Rtry.	...	B	1/6	SO_2	9	.....	5#	L.S.F.	32-33 oz.	Therm.	.....	Flooded	....
	J	Con.	Rtry	...	B	1/6	SO_2	9	.....	5#	L.S.F	32-33 oz.	Therm.	.....	Flooded	....
	Late J	Con.	Rtry.	...	B	1/6	SO_2	9	.....	5½#	L.S.F.	32-33 oz.	Therm.	.....	Flooded	....
	JP	Con.	Rtry.	...	B	1/6	SO_2	9	.....	5#	L.S.F.	32-33 oz.	Therm.	.....	Flooded	....
	Late JP	Con.	Rtry.	...	B	1/6	SO_2	9	.....	5½#	L.S.F.	32-33 oz.	Therm.	.....	Flooded	....
	P66	Con.	Rtry.	...	B	1/6	SO_2	8	.....	5½#	L.S.F.	32-33 oz.	Therm.	.....	Flooded	....
	PP66	Con.	Rtry.	...	B	1/6	SO_2	8	.....	5½#	L.S.F.	32-33 oz.	Therm.	.....	Flooded	....
	D66	Con.	Rtry.	...	B	1/6	SO_2	8	.....	5¾#	L.S.F.	32-33 oz.	Therm.	.....	Flooded	....
	D5, K	Con.	Rtry.	...	B	1/6	SO_2	8	.....	5½#	L.S.F	32-33 oz.	Therm	.....	Flooded	....
	KP and M	Con.	Rtry	...	B	1/6	SO_2	8	.....	5½#	L.S.F.	32-33 oz.	Therm	.....	Flooded	....
	R	Con.	Rtry.	...	B	1/6	SO_2	11	.....	5¾#	L.S.F.	32-33 oz.	Therm.	.....	Flooded	....
	W	Con.	Rtry.	...	B	1/6	SO_2	6	.....	3#	Ex. Va.	32-33 oz.	Therm.	.....	Tube	....
1934	T20	Con.	Rtry.	...	B	1/6	SO_2	9	.....	5#	L.S.F.	32 oz.	Therm.	.....	Flooded	....
	A45	Con.	Rtry	...	B	1/6	SO_2	9	.....	5#	L.S.F	32 oz.	Therm.	.....	Flooded	....
	S47	Con.	Rtry.	...	B	1/6	SO_2	9	.....	5#	L.S.F	32 oz.	Therm.	.....	Flooded	....
	SP47	Con.	Rtry.	...	B	1/6	SO_2	9	.....	5#	L.S.F.	32 oz.	Therm.	.....	Flooded	....
	A55	Con.	Rtry.	...	B	1/6	SO_2	9	.....	5#	L.S.F.	32 oz.	Therm.	.....	Flooded	....
	A71	Con	Rtry.	...	B	1/6	SO_2	7	.....	5#	L.S.F	32 oz.	Therm	.....	Flooded	....
	S55	Con.	Rtry.	...	B	1/6	SO_2	9	.....	5#	L.S.F.	32 oz	Therm.	.....	Flooded	....
	SP55	Con	Rtry.	...	B	1/6	SO_2	9	.....	5#	L.S.F	32 oz.	Therm.	.....	Flooded	....
	L54	Con.	Rtry.	...	B	1/6	SO_2	9	.....	5#	L.S.F.	32 oz.	Therm.	.....	Flooded	....
	SP71	Con.	Rtry	...	B	1/6	SO_2	7	.....	5½#	L.S.F.	32 oz.	Therm	.....	Flooded	....
	P54	Con	Rtry.	...	B	1/6	SO_2	9	.....	5½#	L.S.F.	32 oz.	Therm.	.....	Flooded	....
	L67	Con.	Rtry	...	B	1/6	SO_2	8	.....	5½#	L.S.F.	32 oz.	Therm.	.....	Flooded	....
	S71	Con	Rtry.	...	B	1/6	SO_2	7	.....	5½#	L.S.F.	32 oz	Therm.	.....	Flooded	....
	P78	Con.	Rtry.	...	B	1/6	SO_2	7	.....	5½#	L.S.F.	32 oz.	Therm.	.....	Flooded	....
	P91	Con.	Rtry	...	B	1/4	SO_2	11	.....	5½#	L.S.F.	32 oz.	Therm.	.....	Flooded	....

496. NORGE, Continued

	P110	Con.	Rtry.	...	B	1/4	SO_2	6	.....	3#	Ex. Va.	32 oz.	Therm.	.....	Dry	....
1935	T20	Con.	Rtry.	...	B	1/6	SO_2	9	.....	4½#	L.S.F.	32 oz.	Therm.	.....	Flooded	....
	E425	Con.	Rtry.	...	B	1/6	SO_2	9	.....	5¼#	L.S.F.	32 oz.	Therm.	.....	Flooded	....
	E625	Con.	Rtry	...	B	1/6	SO_2	9	.....	5¼#	L.S.F	32 oz.	Therm.	.....	Flooded	....
	L519	Con	Rtry.	...	B	1/6	SO_2	9	.....	5¼#	L.S.F.	32 oz.	Therm.	.....	Flooded	....
	P519	Con.	Rtry.	...	B	1/6	SO_2	9	.....	5¼#	L.S.F.	32 oz.	Therm.	.....	Flooded	....
	L621	Con.	Rtry	...	B	1/6	SO_2	8	.....	5½#	L.S.F.	32 oz.	Therm.	.....	Flooded	....
	P621	Con.	Rtry.	...	B	1/6	SO_2	8	.....	5½#	L.S.F.	32 oz.	Therm.	.....	Flooded	....
	L720	Con.	Rtry.	...	B	1/6	SO_2	7	.....	5¾#	L.S.F.	32 oz.	Therm.	.....	Flooded	....
	P720	Con.	Rtry.	...	B	1/6	SO_2	7	.....	5¾#	L.S.F.	32 oz.	Therm.	.....	Flooded	....
	L804	Con.	Rtry.	...	B	1/4	SO_2	10	.....	6#	L.S.F.	32 oz.	Therm.	.....	Flooded	....
	P804	Con.	Rtry.	...	B	1/4	SO_2	10	.....	6#	L.S.F.	32 oz.	Therm.	.....	Flooded	....
	P953	Con.	Rtry.	...	B	1/4	SO_2	10	.....	6#	L.S.F.	32 oz.	Therm.	.....	Flooded	....
	P1117	Con.	Rtry.	...	B	1/4	SO_2	10	.....	10#	L.S.F.	34 oz.	Therm.	.....	Flooded	....

497. O'KEEFE & MERRITT*—O'KEEFE & MERRITT CO., 370 EAST OLYMPIC BLVD. LOS ANGELES

1934	344	Con.	Recip.	2	B	1/6	SO_2	.....	.....	2.5#	Therm. Ex. Va.	22 oz.	Therm.	.....	Shell	....
	345	Con.	Recip.	2	B	1/6	SO_2	.....	.....	2.5#	Therm. Ex. Va.	22 oz.	Therm.	.....	Shell	....
	346	Con	Recip.	2	B	1/6	SO_2	.....	.....	3#	Therm. Ex. Va.	22 oz.	Therm.	.....	Shell	....
	634	Con.	Recip.	2	B	1/6	SO_2	.....	.....	3#	Therm. Ex. Va.	22 oz.	Therm.	.....	Shell	....
	734	Con.	Recip	2	B	1/6	SO_2	.....	.....	3¼#	Therm. Ex. Va.	22 oz.	Therm.	.....	Shell	....
	1034	Con.	Recip.	2	B	1/4	SO_2	.....	.....	4#	Therm. Ex. Va.	22 oz.	Therm.	.....	Shell	....
1935	354	Con.	Recip.	2	B	1/6	SO_2	.....	.....	2.5#	Therm. Ex. Va.	22 oz.	Therm.	.....	Shell	....
	355	Con.	Recip.	2	B	1/6	SO	.....	.....	2.5#	Therm. Ex. Va.	22 oz.	Therm.	.....	Shell	....
	356	Con.	Recip.	2	B	1/6	SO_2	.....	.....	3#	Therm. Ex. Va.	22 oz.	Therm.	.....	Shell	....

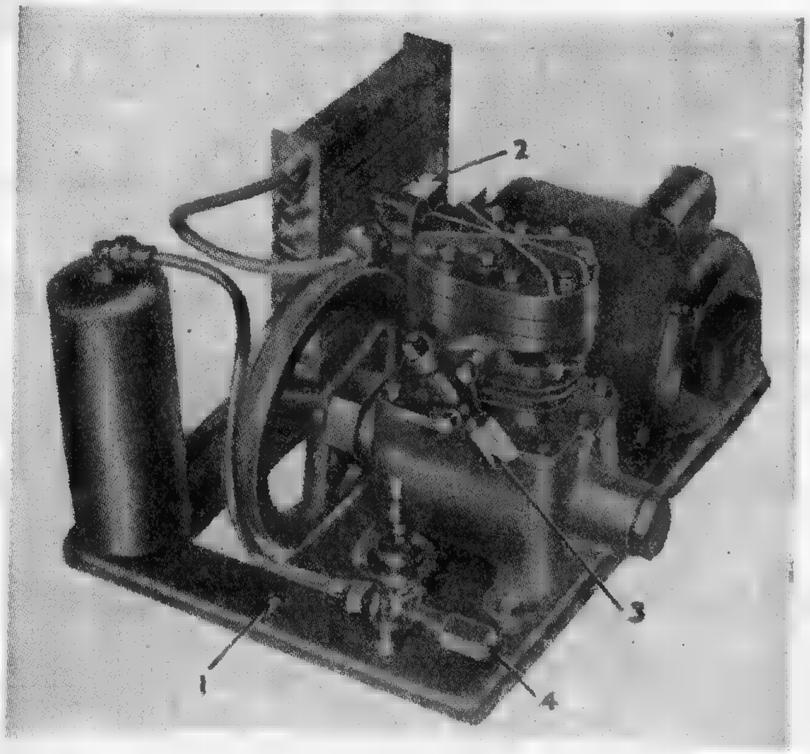


Fig. 349. The O'Keefe and Merritt condensing unit
1. Mounting bolt holes; 2. D.S.V.; 3. S.S.V.; 4. L.R.S.V.
(Courtesy of: O'Keefe & Merritt Company)

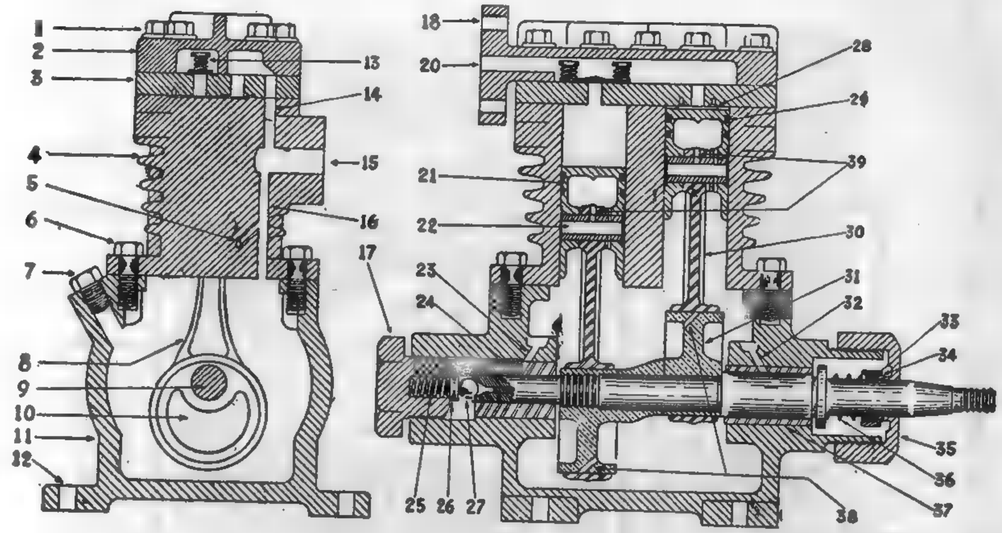


Fig. 350. The O'Keefe and Merritt Compressor

1. Cap screws
2. Cylinder head
3. Valve plate
4. Cylinder block
5. Oil return hole
6. Cylinder and crankcase cap screws
7. Oil filler plug
8. Connecting rod
9. Crankshaft
10. Eccentric
11. Crankcase
12. Mounting holes
13. Exhaust valve assembly
14. Intake port
15. Suction line valve port
16. Oil return hole
17. Thrust plug
18. Discharge service valve cap screw hole
20. Exhaust port
21. Piston
22. Piston pin
23. Oil hole for shaft
24. Bronze bearing
25. Thrust spring
26. Thrust pin
27. Thrust ball
28. Intake valve
29. Piston ring
30. Connecting rod
31. Eccentric
32. Oil hole for shaft and seal
33. Seal packing washer
34. Seal ring
35. Seal nut
36. Seal spring
37. Bronze bearing
38. Oil hole in cams
39. Oil hole in piston pin and connecting rod

(Courtesy of: O'Keefe & Merritt Company)

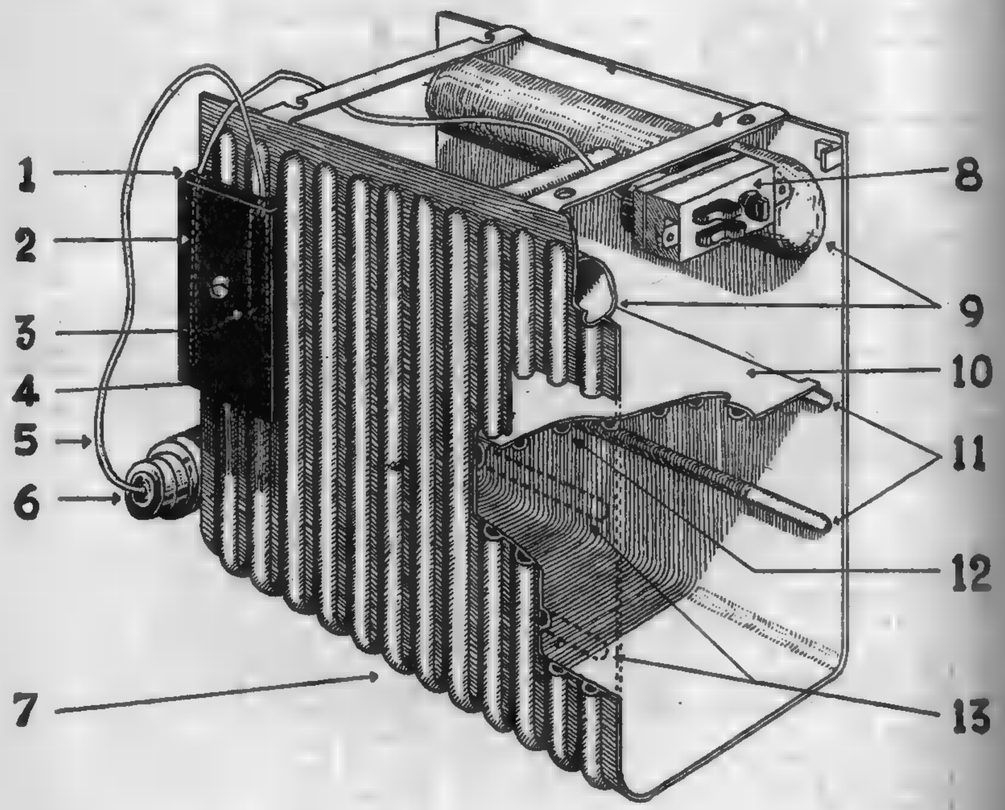


Fig. 351. The O'Keefe and Merritt cooling coil
1. Power element retainer; 2. Motor control power element; 3. Expansion valve power element; 4. Retainer clamp; 5. Expansion valve capillary tube; 6. Expansion valve; 7. Cooling unit; 8. Motor control; 9. Surge chamber; 10. Tray shelf; 11. Shelf supports; 12. Shelf tubes; 13. Shelf supports
(Courtesy of: O'Keefe & Merritt Company)

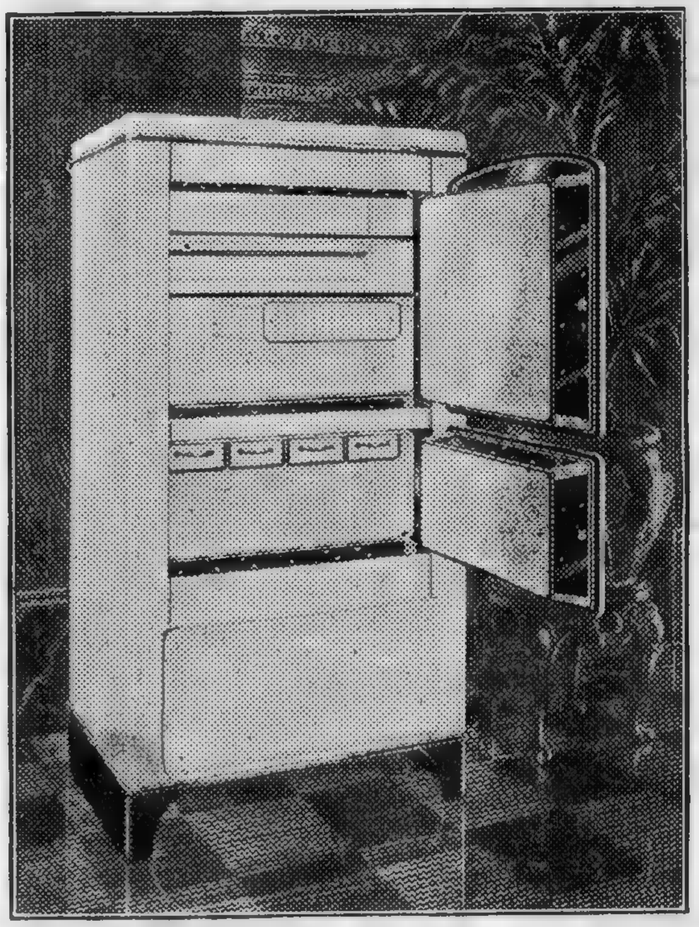


Fig. 352. The Potter refrigerator cabinet. Note the two compartments—the lower one for frozen foods, and for ice cubes, while the upper compartment is for storing foods which require ■ high humidity
(Courtesy of: Potter Refrigerator Corporation)

497. O'KEEFE & MERRITT, Continued

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure	Quantity of Refrigerant	Refrigerant Control	Quantity of Oil	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
1935	635	Con.	Recip.	2	B	1/6	SO_2	.....	.....	3#	Therm. Ex. Va.	22 oz.	Therm.	.....	Shell	....
	735	Con.	Recip.	2	B	1/6	SO_2	.....	.....	3¼#	Therm. Ex. Va.	22 oz.	Therm.	.....	Shell	....
	1035	Con.	Recip.	2	B	¼	SO_2	.....	.....	4#	Therm. Ex. Va.	22 oz.	Therm.	.....	Shell	....

498. POTTER—POTTER REFRIGERATOR CORP., 220 DELAWARE AVE., BUFFALO, N. Y.

1935	....	Con.	Recip.	1	B	1/6	M. C.	.....	1½#	.....	Ex. Va.	.. ..	Therm.	.....	Tube	....
1935	L45, L55	Con.	Recip.	1	B	1/6	M. C.	.....	1½#	1#	Ex. Va.	¾ pt.	Therm.	.....	Tube	....
1935	L65, L75															
1935	D85, D105	Con.	Recip.	1	B	1/6	M. C.	.....	1½#	1#	Ex. Va.	¾ pt.	Therm.	.....	*	....
1935	D135															
1935	D155	Con.	Recip.	1	B	¼	M. C.	.....	1½#	1½#	Ex. Va.	¾ pt.	Therm.	.....	*	....

499. RICE—ISAAC L. RICE, JR., 295 FIFTH AVE., NEW YORK, N. Y.

1928	A	Con.	Recip.	1	B	¼	M. C.	.....	.....	2#	Cap. T.	2 pt.	Therm.	.....	Cast	....
1930	H	Con.	Recip.	1	D	1/6	M. C.	.....	.....	½#	Cap. T.	1 pt.	Therm.	.....	Shell	....

500. SANITARY—SANITARY REFRIGERATOR CO., FOND DU LAC, WIS.

	S20	Con.	Recip.	1	B	1/6	SO_2	.....	.....	3¼#	L.S.F.	¾ pt.	Therm.	.....	Flooded	....
	K02	Con.	Recip.	1	B	1/6	SO_2	.....	.....	3½#	L.S.F.	¾ pt.	Therm.	.....	Flooded	....
	S42	Con.	Recip.	1	B	1/6	SO_2	.....	.....	3#	L.S.F.	¾ pt.	Therm.	.....	Flooded	....
	S84	Con.	Recip.	1	B	1/6	SO_2	.....	.....	3¼#	L.S.F.	¾ pt.	Therm	.....	Flooded	....

500. SANITARY, Continued

	L-28	Con.	Recip.	1	B	¼	SO_2	.....	.....	3¾#	L.S.F.	¾ pt.	Therm.	.....	Flooded	....
	L-38	Con.	Recip.	1	B	¼	SO_2	.....	.....	4½#	L.S.F.	¾ pt.	Therm.	.....	Flooded	....
	L-50	Con.	Recip.	1	B	¼	SO_2	.....	.....	6#	L.S.F.	¾ pt.	Therm.	.....	Flooded	....
1935	AB	Con.	Recip.	1	B	1/6	M. C.	.....	.....	1#	Ex. Va.	⅜ pt.	Therm.	.....	Tube	....
1935	AD	Con.	Recip.	2	B	1/5	M. C.	.....	.....	1½#	Ex. Va.	1¾ pt.	Therm.	.....	Tube	....

501. SERVEL—SERVEL, INC., EVANSVILLE, IND.

	1	Con.	Recip.	2	B	¼	M. C.	.....	.....	2¼#	H.S.F.	1¾ pt.	Press.	.....	Brine	....
	2	Con	Recip.	2	B	¼	M. C.	.....	.....	2¼#	H.S.F.	1¾ pt.	Press.	.....	Brine	....
	21	Con.	Recip.	2	B	¼	M. C.	.....	.....	2¼#	H.S.F.	1¾ pt.	Press.	.....	Brine	....
	13A	Con.	Recip.	1	B	1/6	M. C.	.....	.....	1¾#	L.S.F.	1 pt	Therm.	.....	Tube	....
	14A	Con.	Recip.	1	B	1/6	M. C.	.....	.....	1¾#	L.S.F.	1¾ pt.	Therm.	.....	Tube	....
	23A	Con.	Recip.	2	B	¼	M. C.	.....	.....	4#	L.S.F.	1¾ pt.	Press.	.....	Tube	....
	24A	Con.	Recip	2	B	¼	M. C.	.....	.....	4#	L.S.F	1¾ pt.	Press.	.....	Tube	....

502. SPARTON—THE SPARKS-WITHINGTON CO., JACKSON, MICH.

1933	Sptn.	S.H.	Recip.	2	D	1/5	SO_2	.....	.....	25 oz.	Ex. Va.	14 oz.	Therm.	.....	Tube	....
1934	Sptn.	S.H.	Recip.	2	D	1/5	SO_2	.....	.....	25 oz.	Ex. Va.	14 oz.	Therm.	.....	Tube	....
1935	Sptn.	Con.	Recip.	1	B	1/6	SO_2	.....	.....	20 oz.	Ex. Va.	14 oz.	Therm.	.....	Tube	....

503. *STARR FREEZE—STARR COMPANY. RICHMOND, IND.

Household Refrigerators

	T	Con.	Recip.	1	B	⅛	SO_2	.. ..	.....	2#	Ex. Va.	15 oz.	Therm.	.....	Tube	....
	R	Con.	Recip.	1	B	1/6	SO_2	.....	.....	2½#	Ex. Va.	15 oz.	Therm.	.....	Tube	....
	N	Con.	Recip.	2	B	1/6	M. C.	.....	.....	1½#	Ex. Va.	10 oz.	Therm.	.....	Tube	....
	Q	Con.	Recip.	2	B	1/5	M. C.	.....	.....	1½#	Ex. Va.	10 oz.	Therm.	.....	Tube	....
	G	Con.	Recip.	2	B	¼	M. C.	.....	.....	3½#	Ex. Va.	22 oz.	Therm.	.....	Tube	....
	H	Con.	Recip.	2	B	1/5	M. C.	.....	.....	3½#	Ex. Va.	22 oz.	Therm.	.....	Tube	....

Condensing Units in Commercial Line

	JRSA	Con.	Recip.	2	B	1/6	SO_2	.....	.....	2½#	Ex. Va.	10 oz.	Therm. or Press.	.....	.....	....
	J1SA	Con.	Recip.	2	B	1/6	SO_2	.....	.....	2½#	.....	10 oz.	.....	.....	.....	....
	J3MA	Con.	Recip.	2	B	1/6	M. C.	.....	.....	1½#	.....	10 oz.	.....	.....	.....	....

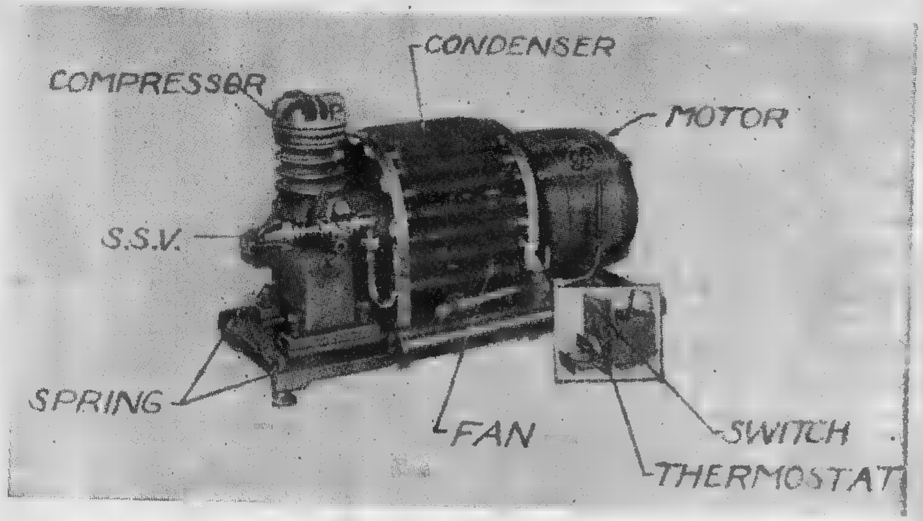


Fig. 353. The Rice condensing unit
(Courtesy of: Isaac Rice Inc.)

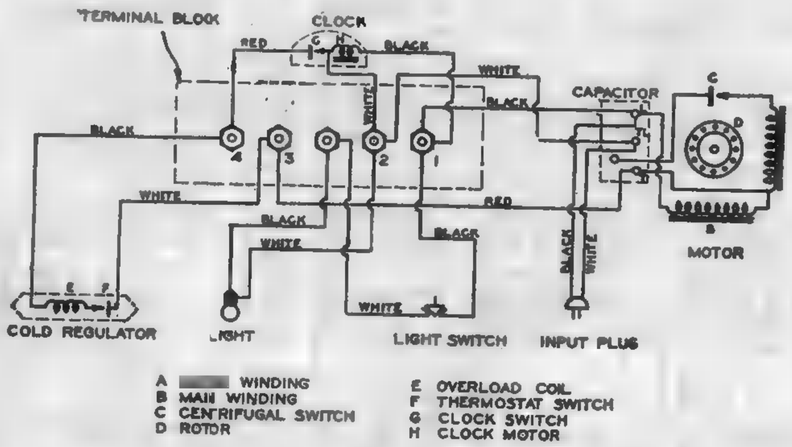


Fig. 354. A Sparton wiring diagram showing an automatic defrosting clock hook-up
(Courtesy of: The Sparks-Withington Company)

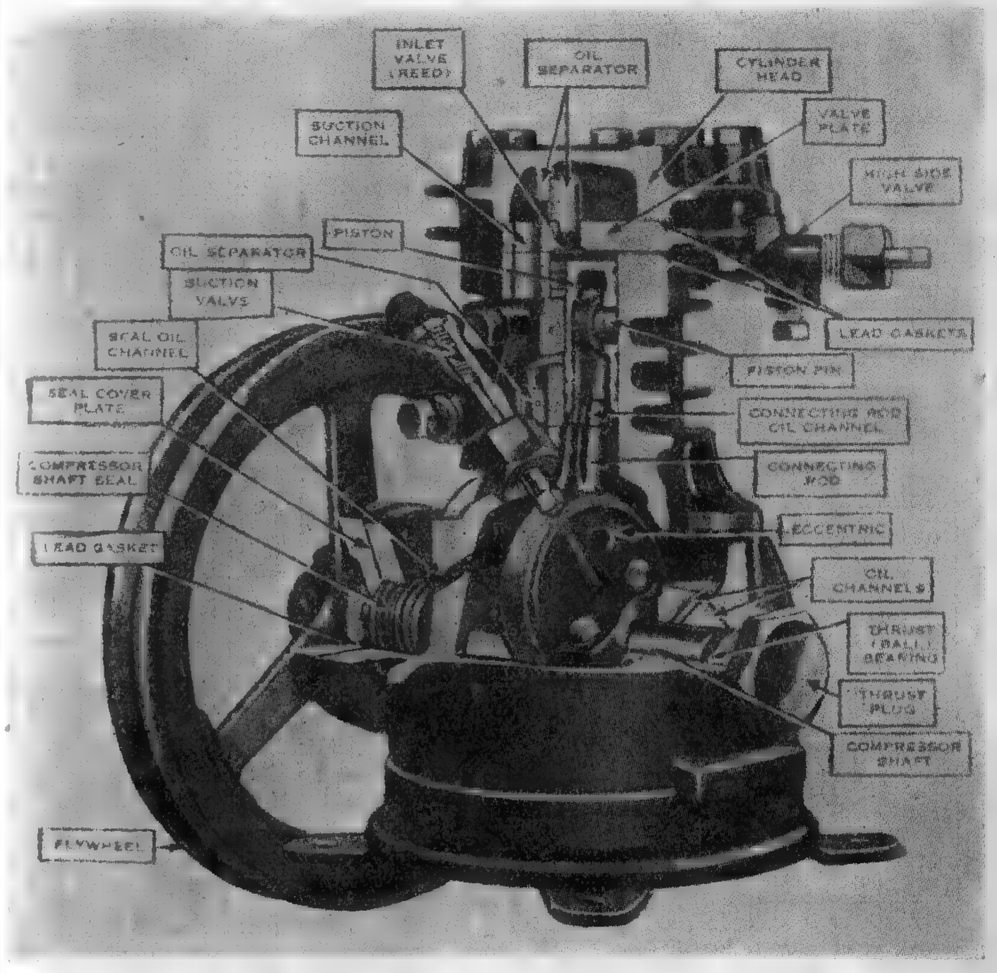


Fig. 355. The 1935 Sparton compressor cut-a-way
(Courtesy of: The Sparks-Withington Company)

503. *STARR FREEZE, Continued

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure	Quantity of Refrigerant	Refrigerant Control	Quantity of Oil	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
	J5SA	Con.	Recip.	2	B	1/6	SO_2	.....	.....	2½#	.....	10 oz.	.....	.....	.....	....
	J7MA	Con.	Recip.	2	B	1/6	M. C.	.....	.....	1½#	.....	10 oz.	.....	.....	.....	....
	J8MW	Con.	Recip.	2	B	1/6	M. C.	.....	.....	1½#	.....	10 oz.	.....	.....	.....	....
	ATSA	Con.	Recip.	1	B	1/6	SO_2	.....	.....	2#	.....	15 oz.	.....	.....	.....	....
	ARSA	Con.	Recip.	1	B	1/6	SO_2	.....	.....	2½#	.....	15 oz.	.....	.....	.....	....
	A1SA	Con.	Recip.	1	B	1/6	SO_2	.....	.....	2½#	.....	15 oz.	.....	.....	.....	....
	A2SA	Con.	Recip.	1	B	1/6	SO_2	.....	.....	2½#	.....	15 oz.	.....	.....	.....	....
	A3MA	Con.	Recip.	1	B	1/6	M. C.	.....	.....	4½#	.....	15 oz.	.....	.....	.....	....
	BOMA	Con.	Recip.	2	B	¼	M. C.	.....	.....	3½#	.....	22 oz	.....	.....	.....	....
	B1SA	Con.	Recip.	2	B	¼	SO_2	.....	.....	5#	.....	22 oz.	.....	.....	.....	....
	B3MA	Con.	Recip.	2	B	1/3	M. C.	.....	.....	3½#	.....	22 oz.	.....	.....	.....	....
	B5SA	Con.	Recip.	2	B	1/3	SO_2	.....	.....	6#	.....	22 oz.	.....	.....	.....	....
	B7MA	Con.	Recip.	2	B	½	M. C.	.....	.....	4½#	.....	22 oz.	.....	.....	.....	....
	B9SA	Con.	Recip.	■	B	½	SO_2	.....	.....	6#	.....	22 oz.	.....	.....	.....	....
	B11MA	Con.	Recip.	2	B	¾	M. C.	.....	.....	4½#	.....	22 oz.	.....	.....	.....	....
	B2SW	Con.	Recip.	2	B	¼	SO_2	.....	.....	5#	.....	22 oz	.....	.....	.....	....
	B4MW	Con.	Recip.	2	B	1/6	M. C.	.....	.....	3½#	.....	22 oz.	.....	.....	.....	....
	B6SW	Con.	Recip.	2	B	1/3	SO_2	.....	.....	6#	.....	22 oz.	.....	.....	.....	....
	B8MW	Con.	Recip.	2	B	½	M. C.	.....	.....	4½#	.....	22 lbs.	.....	.....	.....	....
	B10SW	Con.	Recip.	2	B	½	SO_2	.....	.....	6#	.....	22 oz.	.....	.....	.....	....
	D1SA	Con.	Recip.	2	B	½	SO_2	.....	.....	5#	.....	2 qts.	.....	.....	.....	....
	D3MA	Con.	Recip.	2	B	¾	M. C.	.....	.....	4#	.....	2 qts.	.....	.....	.....	....
	D5SA	Con.	Recip.	2	B	¾	SO_2	.....	.....	6#	.....	2 qts.	.....	.....	.....	....
	D7MA	Con.	Recip.	2	B	1	M. C.	.....	.....	5#	.....	2 qts.	.....	.....	.....	....
	D9SA	Con.	Recip.	2	B	1	SO_2	.....	.....	7#	.....	2 qts.	.....	.....	.....	....
	DD11MA	Con.	Recip.	2	B	1½	M. C.	.....	.....	6#	.....	2 qts.	.....	.....	.....	....
	D2SW	Con.	Recip.	■	B	½	SO_2	.....	.....	5#	.....	2 qts.	.....	.....	.....	....
	D4MW	Con.	Recip.	2	B	¾	M. C.	.....	.....	4#	.....	2 qts.	.....	.....	.....	....
	D6SW	Con.	Recip.	2	B	¾	SO_2	.....	.....	6#	.....	2 qts.	.....	.....	.....	....
	D8MW	Con.	Recip.	2	B	1	M. C.	.....	.....	5#	.....	2 qts.	.....	.....	.....	....
	DD11SW	Con.	Recip.	2	B	1	SO_2	.....	.....	7#	.....	2 qts.	.....	.....	.....	....
	DD12MW	Con.	Recip.	2	B	1½	M. C.	.....	.....	6#	.....	2 qts.	.....	.....	.....	....
	E1SA	Con.	Recip.	2	B	1½	SO_2	.....	.....	12#	.....	7½ pts.	.....	.....	.....	....
	E3MA	Con.	Recip.	2	B	2	M. C.	.....	.....	8½#	.....	7½ pts.	.....	.....	.....	....
	E5SA	Con.	Recip.	2	B	2	SO_2	.....	.....	15#	.....	7½ pts.	.....	.....	.....	....
	E7MA	Con.	Recip.	2	B	3	M. C.	.....	.....	10#	.....	7½ pts.	.....	.....	.....	....
	E2SW	Con.	Recip.	2	B	1½	SO_2	.....	.....	12#	.....	7½ pts.	.....	.....	.....	....
	E4MW	Con.	Recip.	2	B	2	M. C.	.....	.....	8½#	.....	7½ pts.	.....	.....	.....	....
	E6SW	Con.	Recip.	2	B	2	SO_2	.....	.....	15#	.....	7½ pts.	.....	.....	.....	....
	E8MW	Con.	Recip.	2	B	3	M. C.	.....	.....	10#	.....	7½ pts.	.....	.....	.....	....
	D108MAW	Con.	Recip.	2	B	1	M. C.	.....	.....	5#	.....	7½ pts.	.....	.....	.....	....
	DD110SAW	Con.	Recip.	2	B	1	SO_2	.....	.....	7#	.....	7½ pts.	.....	.....	.....	....
	E102SAW	Con.	Recip.	2	B	1½	SO_2	.....	.....	12#	.....	7½ pts.	.....	.....	.....	....
	E104MAW	Con.	Recip.	2	B	2	M. C.	.....	.....	8½#	.....	7½ pts.	.....	.....	.....	....
	E106SAW	Con.	Recip.	2	B	2	SO_2	.....	.....	18#	.....	7½ pts.	.....	.....	.....	....
	E108MAW	Con.	Recip.	2	B	3	M. C.	.....	.....	12#	.....	7½ pts.	.....	.....	.....	....
	GM4W	Con.	Recip.	4	B	5	M. C.	.....	.....	25#	.....	3 gal.	.....	.....	.....	....
	GM5W	Con.	Recip.	4	B	5	M. C.	.....	.....	25#	.....	3 gal.	.....	.....	.....	....
	GM6W	Con.	Recip.	4	B	5	M. C.	.....	.....	25#	.....	3 gal.	.....	.....	.....	....
	GF7W	Con.	Recip.	4	B	5	F-12	.....	.....	30#	.....	3 gal.	.....	.....	.....	....
	GF8W	Con.	Recip.	4	B	5	F-12	.....	.....	30#	.....	3 gal.	.....	.....	.....	....
	GF9W	Con.	Recip.	4	B	5	F-12	.....	.....	30#	.....	3 gal.	.....	.....	.....	....
	FM10W	Con.	Recip.	2	B	3	M. C.	.....	.....	15#	.....	1½ gal.	.....	.....	.....	....
	FM11W	Con.	Recip.	2	B	3	M. C	.....	.....	15#	.....	1½ gal.	.....	.....	.....	....
	FM12W	Con.	Recip.	2	B	3	M. C.	.....	.....	15#	.....	1½ gal.	.....	.....	.....	....
	FF15W	Con.	Recip.	2	B	3	F-12	.....	.....	18#	.....	1½ gal.	.....	.....	.....	....
	FF16W	Con.	Recip.	2	B	3	F-12	.....	.....	18#	.....	1½ gal.	.....	.....	.....	....
	FF17W	Con.	Recip.	2	B	3	F-12	.....	.....	18#	.....	1½ gal.	.....	.....	.....	....
Condensing Unit for Air-Conditioning																
	G20MW	Con.	Recip.	4	B	7½	M. C.	.....	.....	30#	.....	3 gal.	.....	.....	.....	....
	G30MW	Con.	Recip.	4	B	7½	M. C.	.....	.....	30#	.....	3 gal.	.....	.....	.....	....
	G40MW	Con.	Recip.	4	B	7½	M. C.	.....	.....	30#	.....	3 gal.	.....	.....	.....	....

*Under the Model Column—W represents water-cooled cooling units while the letter A represents air-cooled units.

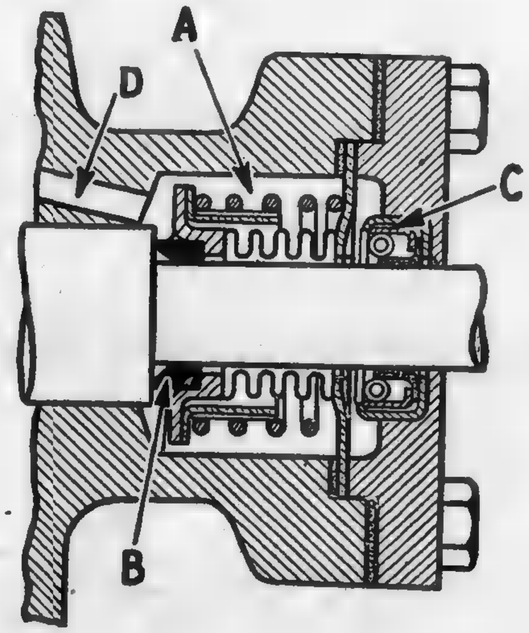


Fig. 356. The Stewart-Warner crankshaft seal showing the packing ring A. Bellows spring; B. Seal ring; C. Packing; D. Oil hole
(Courtesy of: Stewart-Warner Corporation)

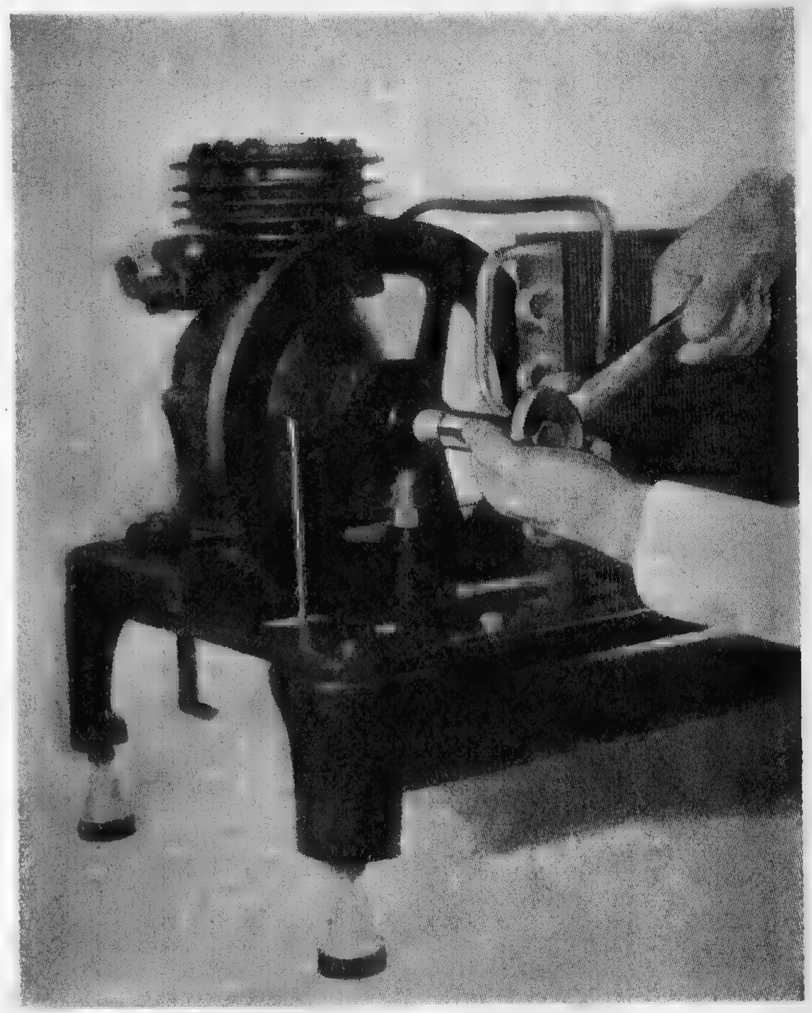


Fig. 357. Showing a method of removing the Stewart-Warner flywheel
(Courtesy of: Stewart-Warner Corporation)

503. *STARR FREEZE, Continued

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure	Quantity of Refrigerant	Refrigerant Control	Quantity of Oil	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
	G50MW	Con.	Recip.	4	B	10	M. C.	.....	.....	40#	.....	3 gal.	.....	.....	.....	....
	G60FW	Con.	Recip.	4	B	7½	F-12	.....	.....	35#	.....	3 gal.	.....	.....	.....	....
	G70FW	Con.	Recip.	4	B	7½	F-12	.....	.....	35#	.....	3 gal.	.....	.....	.....	....
	G80FW	Con.	Recip.	4	B	7½	F-12	.....	.....	35#	.....	3 gal.	.....	.....	.....	....
	G90FW	Con.	Recip.	4	B	10	F-12	.....	.....	50#	.....	3 gal.	.....	.....	.....	....
	F14MW	Con.	Recip.	2	B	5	M. C.	.....	.....	18#	.....	1½ gal.	.....	.....	.....	....
	F18FW	Con.	Recip.	2	B	5	F-12	.....	.....	24#	.....	1½ gal.	.....	.....	.....	....
Commercial Refrigerators Complete																
	I	Con.	Recip.	2	B	⅛	M. C.	.....	.....	3½#	Ex. Va.	22 oz.	Press.	.....	Tinned Tubes	....
	S	Con.	Recip.	2	B	½	M. C.	.....	.....	4½#	Ex. Va.	22 oz.	Press.	.....	Tinned Tubes	....
	J	Con.	Recip.	2	B	½	M. C.	.....	.....	4½#	Ex. Va.	22 oz.	Press.	.....	Tinned Tubes	....
	K	Con.	Recip.	2	B	¾	M. C.	.....	.....	4#	Ex. Va.	22 oz.	Press.	.....	Tinned Tubes	....
	L	Con.	Recip.	2	B	1½	M. C.	.....	.....	7#	Ex. Va.	22 oz.	Press.	.....	Tinned Tubes	....
Display Cases																
	R400	Con.	Recip.	2	B	⅛	M. C.	.....	.....	3½#	Ex. Va.	22 oz.	Press.	.....	Tinned Tubes	....
	R401	Con.	Recip.	2	B	⅛	M. C.	.....	.....	3½#	Ex. Va.	22 oz.	Press.	.....	Tinned Tubes	....
	R402	Con.	Recip.	2	B	½	M. C.	.....	.....	4½#	Ex. Va.	22 oz.	Press.	.....	Tinned Tubes	....
	R403	Con.	Recip.	2	B	½	M. C.	.....	.....	4½#	Ex. Va.	22 oz.	Press.	.....	Tinned Tubes	....

*Under the Model Column—W represents water-cooled cooling units while the letter A represents air-cooled units.

504. STEWART-WARNER—STEWART-WARNER CORPORATION, CHICAGO, ILL.

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure	Quantity of Refrigerant	Refrigerant Control	Quantity of Oil	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
1932	89	Con.	Recip.	1	B	⅛	SO_2	.....	.....	4¼#	L.S.F.	14 oz.	Therm.	.....	Flooded	....
	90	Con.	Recip.	1	B	⅛	SO_2	.....	.....	4¼#	L.S.F.	14 oz.	Therm.	.....	Flooded	....
	91	Con.	Recip.	1	B	⅛	SO_2	.....	.....	4¼#	L.S.F.	14 oz.	Therm.	.....	Flooded	....
	92	Con.	Recip.	1	B	⅛	SO_2	.....	.....	4¼#	L.S.F.	14 oz.	Therm.	.....	Flooded	....
1933	40	Con.	Recip.	2	B	⅛	SO	.....	.....	1¾#	Ex. Va.	7 oz.	Therm.	.....	Tube	....
	45	Con.	Recip.	2	B	⅛	SO_2	.....	.....	1¾#	Ex. Va.	7 oz.	Therm.	.....	Tube	....
	55	Con.	Recip.	2	B	⅛	SO_2	.....	.....	1¾#	Ex. Va.	7 oz.	Therm.	.....	Tube	....
	77	Con.	Recip.	2	B	⅛	SO_2	.....	.....	1¾#	Ex. Va.	7 oz.	Therm.	.....	Tube	....
1934	454	Con.	Recip.	2	B	⅛	SO_2	.....	.....	5#	L.S.F.	22 oz.	Therm.	.....	Flooded	....
	554-574	Con.	Recip.	2	B	⅛	SO_2	.....	.....	5#	L.S.F.	22 oz.	Therm.	.....	Flooded	....
	704-724	Con.	Recip.	2	B	⅛	SO_2	.....	.....	5#	L.S.F.	22 oz.	Therm.	.....	Flooded	....
	564	Con.	Recip.	2	B	⅛	SO_2	.....	.....	5#	L.S.F.	22 oz.	Therm.	.....	Flooded	....
	714	Con.	Recip.	2	B	⅛	SO_2	.....	.....	5#	L.S.F.	22 oz.	Therm.	.....	Flooded	....
	834	Con.	Recip.	2	B	⅛	SO_2	.....	.....	5#	L.S.F.	22 oz.	Therm.	.....	Flooded	....
1935	455	Con.	Recip.	1	B	⅛	SO_2	.....	.....	4#	L.S.F.	15 oz.	Therm.	.....	Flooded	....
	505	Con.	Recip.	1	B	⅛	SO_2	.....	.....	4½#	L.S.F.	15 oz.	Therm.	.....	Flooded	....
	605	Con.	Recip.	1	B	⅛	SO_2	.....	.....	4½#	L.S.F.	15 oz.	Therm.	.....	Flooded	....

505. TRUKOLD AND WARD—MONTGOMERY WARD & CO., INC., CHICAGO, ILL.

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure	Quantity of Refrigerant	Refrigerant Control	Quantity of Oil	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
1932	LW30	S.H.	Recip.	2	D	⅛	SO_2	.....	9″	19 oz.	Ex. Va.	10 oz.	Therm.	.....	Tube	....
	LW40	S.H.	Recip.	2	D	⅛	SO_2	.....	9″	19 oz.	Ex. Va.	10 oz.	Therm.	.....	Tube	....
	LW55	S.H.	Recip.	2	D	⅛	SO_2	.....	9″	19 oz.	Ex. Va.	10 oz.	Therm.	.....	Tube	....
	WW75	S.H.	Recip.	2	D	⅛	SO_2	.....	9″	19 oz.	Ex. Va.	10 oz.	Therm.	.....	Tube	....
1933	450	S.H.	Recip.	2	D	⅛	SO_2	.....	9″	19 oz.	Ex. Va.	16 oz.	Therm.	.....	Tube	....
	480	S.H.	Recip.	2	D	⅛	SO_2	.....	9″	19 oz.	Ex. Va.	16 oz.	Therm.	.....	Tube	....
	657	S.H.	Recip.	2	D	⅛	SO_2	.....	9″	19 oz.	Ex. Va.	16 oz.	Therm.	.....	Tube	....
	872	S.H.	Recip.	2	D	⅛	SO_2	.....	9″	19 oz.	Ex. Va.	16 oz.	Therm.	.....	Tube	....

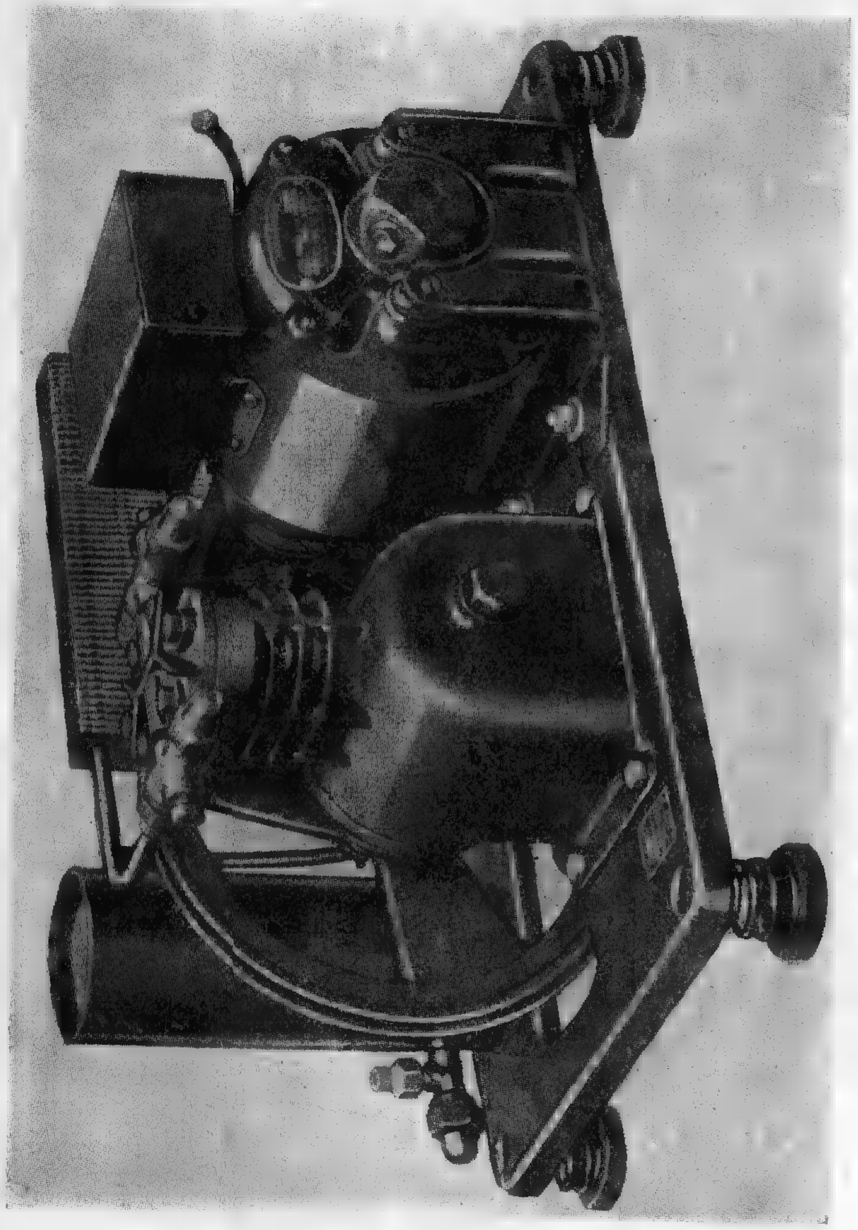


Fig. 358. The Truscon 1936 condensing unit
(Courtesy of: Truscon Steel Corporation)

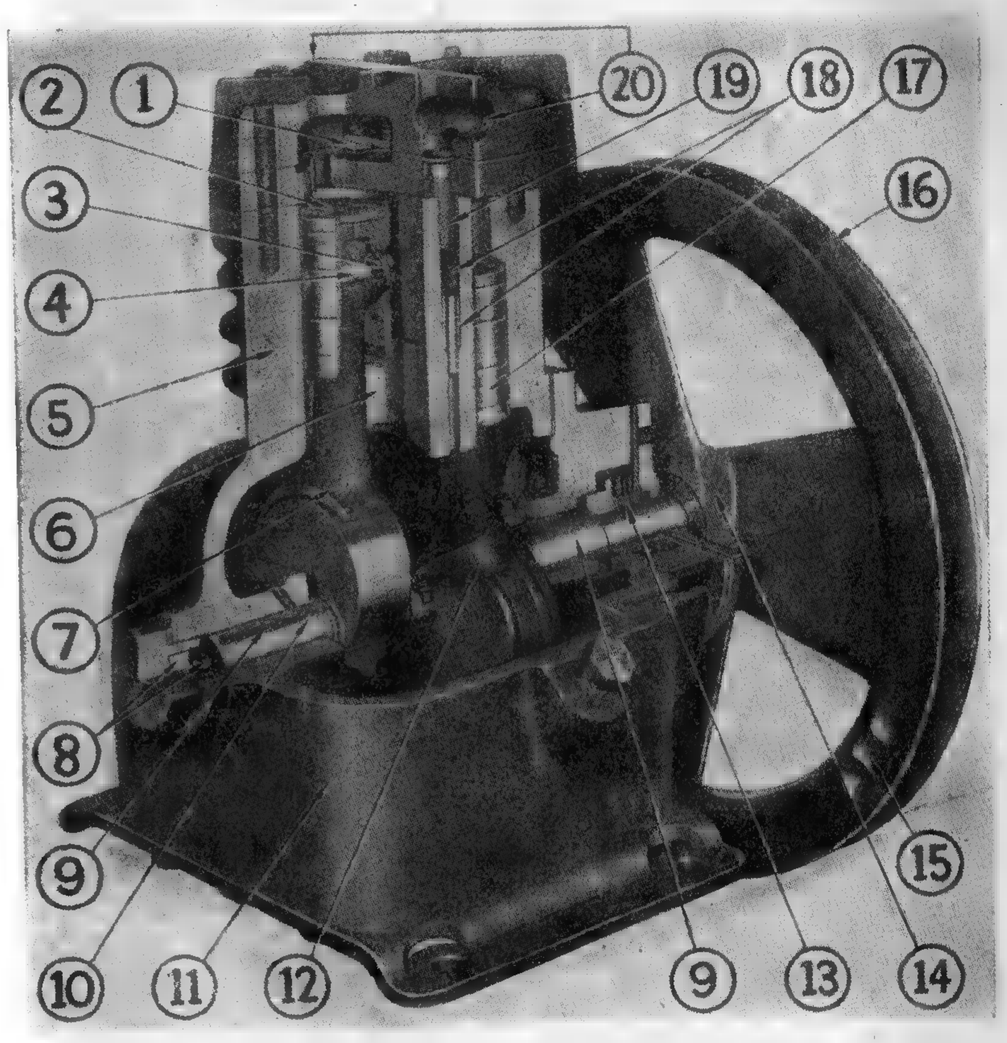


Fig. 359. The Truscon 1936 compressor. The parts are labeled as follows: 1. Exhaust valve; 2. Intake valve; 3. Piston pin; 4. Washers; 5. Cylinder; 6. Cylinder wall; 7. Connecting rod; 8. Thrust ball and disc; 9. Main bearing; 10. Eccentric shaft; 11. Crankcase; 12. Oil distributor; 13. Seal; 14. Fan; 15. Flywheel; 16. V-belt drive; 17. Piston; 18. Oiler; 19. Screen; 20. Service valve openings

(Courtesy of: Truscon Steel Corporation)

505. TRUKOLD AND WARD, Continued

Year	Model	Design	Compre[illegible]	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure	Quantity of Refrigerant	Refrigerant Control	Quantity of Oil	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
1934	425*	Con.	Recip.	1	B	⅛	SO_2	.....	7″	1#	Ex. Va.	12 oz.	Therm.	.....	Tube	....
	650*	Con.	Recip.	2	B	⅛	SO_2	.....	7″	1¼#	Ex. Va.	20 oz.	Therm.	.....	Tube	....
	750*	Con.	Recip.	2	B	⅛	SO_2	.....	7″	1¼#	Ex. Va.	20 oz.	Therm.	.....	Tube	....
1935	400*	Con.	Recip.	1	B	⅛	M. C.	.....	6#	1#	Ex. Va.	12 oz.	Therm.	.....	Tube	....
	550*	Con.	Recip.	1	B	⅛	M. C.	.....	6#	1¼#	Ex. Va.	12 oz.	Therm.	.....	Tube	....
	4250*	Con.	Recip.	1	B	⅛	M. C.	.....	6#	1#	Ex. Va.	12 oz.	Therm.	.....	Tube	....
	6500*	Con.	Recip.	2	B	⅛	M. C.	.....	6#	1¼#	Ex. Va.	20 oz.	Therm.	.....	Tube	....
	7500*	Con.	Recip.	2	B	⅛	M. C.	.....	6#	1¼#	Ex. Va.	20 oz.	Therm.	.....	Tube	....

*The 1933 and 1934 models were called Trukold while the 1934 and 1935 cabinets [illegible] called Wards.

506. TRUSCON—TRUSCON STEEL COMPANY, CLEVELAND, OHIO

1934	AB	Con.	Recip.	1	B	⅛	M. C.	.....	.....	1#	Ex. Va.	½ pt	Therm.	.....	Tube	....
1935	AB	Con.	Recip.	1	B	⅛	M. C.	.....	.....	1#	Ex. Va.	½ pt.	Therm.	.....	Tube	....

507. UNIVERSAL COOLER—UNIVERSAL COOLER CORP., MELVILLE & GREEN, DETROIT, MICH.

1932	....	Con.	Recip.	1	B	⅛	M. C.	.....	.....	2#	Ex. Va.	1 pt.	Therm.	.....	Tube	....
1933	....	Con.	Recip.	1	B	⅛	M. C.	.....	.....	2#	Ex. Va.	1 pt.	Therm.	.....	Tube	....
1934	AB	Con.	Recip.	1	B	⅛	M. C.	.....	.....	1#	Ex. Va.	⅜ pt.	Therm.	.....	Tube	....
	AD	Con.	Recip.	2	B	⅛	M. C.	.....	.....	1½#	Ex. Va.	1½ pt.	Therm.	.....	Tube	....
1935	AB	Con.	Recip.	1	B	⅛	M. C.	.....	.....	1¼#	Ex. Va.	⅜ pt.	Therm.	.....	Tube	....
	AD	Con.	Recip	2	B	⅛	M. C.	.....	.....	1¼#	Ex. Va.	1½ pt.	Therm.	.....	Tube	....

508. UNIVERSAL REFRIGERATOR—LANDERS, FRARY & CLARK, NEW BRITAIN, CONN.

1935	4	Con.	Rtry.	...	B	⅛	SO_2	.....	.....	4#	L.S.F.	32 oz.	Therm.	.....	Plated	....
1935	5 and 6	Con.	Rtry.	...	B	⅛	SO_2	.....	.....	4½#	L.S.F.	32 oz.	Therm.	.....	Plated	....
1935	7 and 8	Con.	Rtry.	...	B	¼	SO_2	.....	.....	5#	L.S.F.	32 oz.	Therm.	.....	Plated	....

509. WAUKESHA—WAUKESHA MOTOR CO., WAUKESHA, WIS.

1934	....	Con.	Recip.	1	D	¾*	M. C.	.....	.....	2#	Ex. Va.	1½ pt.	Therm.	.....	Brine	....
1935	....	Con.	Recip.	1	D	¾*	M. C.	.....	.....	2#	Ex. Va.	1½ pt.	Therm.	.....	Brine	....

*This engine [illegible] gasoline and is designed to run only 2 hours to [illegible] hours out of the [illegible]

510. WELSBACH—WELSBACH CO., GLOUCESTER CITY, N. J.

1927	10	Con.	Recip.	2	B	⅛	Eth. Chl.	.....	.....	20 oz.	Ex. Va.	10 oz.	Therm.	.....	Brine	....
to	20	Con.	Recip.	2	B	¼	Eth. Chl.	.....	.....	20 oz.	Ex. Va.	10 oz.	Therm.	.....	Brine	....
1931	25	Con.	Recip.	2	B	¼	Eth. Chl.	.....	.....	20 oz.	Ex. Va.	10 oz.	Therm.	.....	Brine	....

511. WESTINGHOUSE—WESTINGHOUSE ELECTRIC & MFG. CO., MANSFIELD, OHIO

1930	SD-12	Her.	Recip.	1	D	⅛	SO_2	.....	.....	2½#	Ex. Va.	32 oz.	Therm.	.....	Brine	....
	ASD-16	Her.	Recip.	1	D	⅛	SO_2	.....	.....	2½#	Ex. Va.	32 oz.	Therm.	.....	Brine	....
1931	SD-12	Her.	Recip.	1	D	⅛	SO_2	.....	.....	2½#	Ex. Va.	32 oz.	Therm.	.....	Brine	....
	ASD-16	Her.	Recip.	1	D	⅛	SO_2	.....	.....	2½#	Ex. Va.	32 oz.	Therm.	.....	Brine	....
	SD-16	Her.	Recip.	1	D	⅛	SO_2	.....	.....	2½#	Ex. Va.	32 oz.	Therm.	.....	Brine	....
1931-2	A-122	Her.	Recip.	1	D	⅛	SO_2	.....	.....	4#	H.S.F.	32 oz.	Therm.	.....	Shell	....
1931-2	AB-123	Her.	Recip.	1	D	⅛	SO_2	.....	.....	4#	H.S.F.	32 oz.	Therm.	.....	Shell	....
1931-2	ASD-12	Her.	Recip.	1	D	⅛	SO_2	.....	.....	4#	H.S.F.	32 oz.	Therm.	.....	Shell	....
1931-2	BSD-12	Her.	Recip.	1	D	⅛	SO_2	.....	.....	4#	H.S.F.	32 oz.	Therm.	.....	Shell	....
1932	A-254	Her.	Recip.	2	D	¼	SO_2	.....	.....	7#	H.S.F.	32 oz.	Therm.	.....	Shell	....
to 36	A-258	Her.	Recip.	2	D	¼	SO_2	.....	.....	7#	H.S.F.	32 oz.	Therm.	.....	Shell	....
1933	B-122	Her.	Recip.	1	D	⅛	SO_2	.....	.....	4½#	H.S.F.	32 oz.	Therm.	.....	Shell	....
	B-123	Her.	Recip.	1	D	⅛	SO_2	.....	.....	4½#	H.S.F.	32 [illegible]	Therm.	.....	Shell	....
[illegible]	C-122	Her.	Recip.	1	D[1]	⅛	SO_2	.....	.....	4½#	H.S.F.	32 oz.	Therm.	.....	Shell	....
	C-123	Her.	Recip.	1	D	⅛	SO_2	.....	.....	4½#	H.S.F.	32 oz.	Therm.	.....	Shell	....
	CF-123	Her.	Recip.	1	D	⅛	Freon	.....	.....	6#	H.S.F.	32 oz.	Therm.	.....	Shell	....

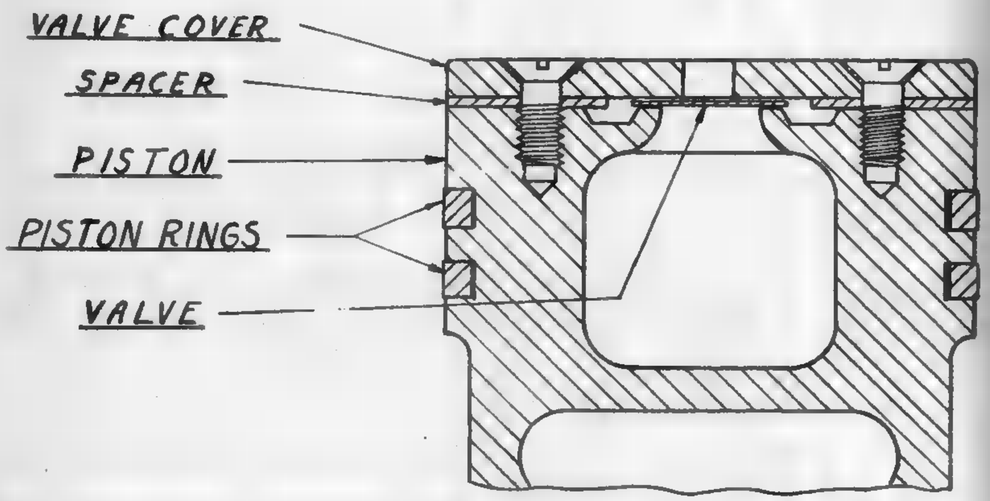


Fig. 360. Details of the Universal Cooler intake valve
(Courtesy of: Universal Cooler Corporation)

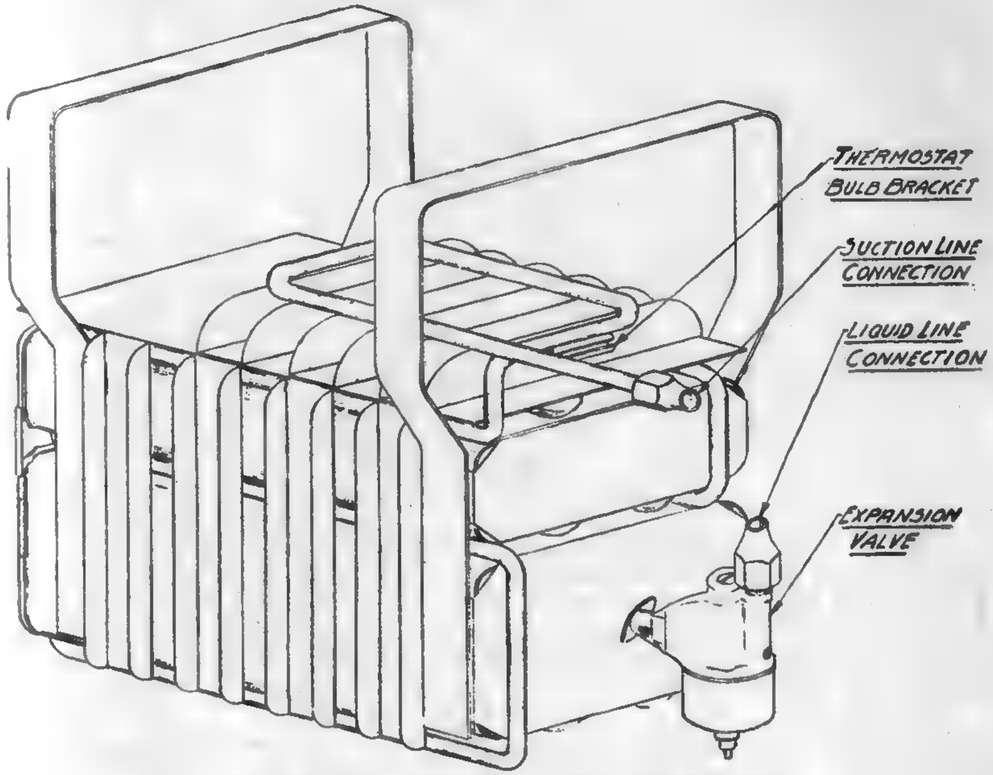


Fig. 361. The Universal Cooler cooling unit
(Courtesy of: Universal Cooler Corporation)

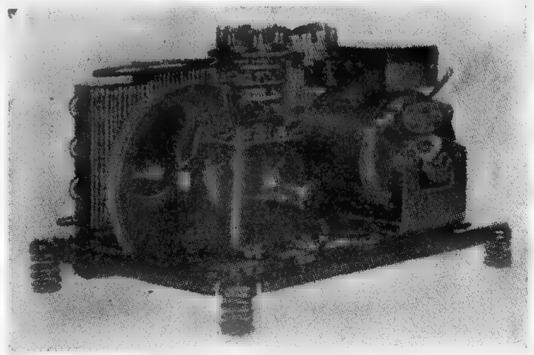


Fig. 362. The Universal Cooler condensing unit
(Courtesy of: Universal Cooler Corporation)

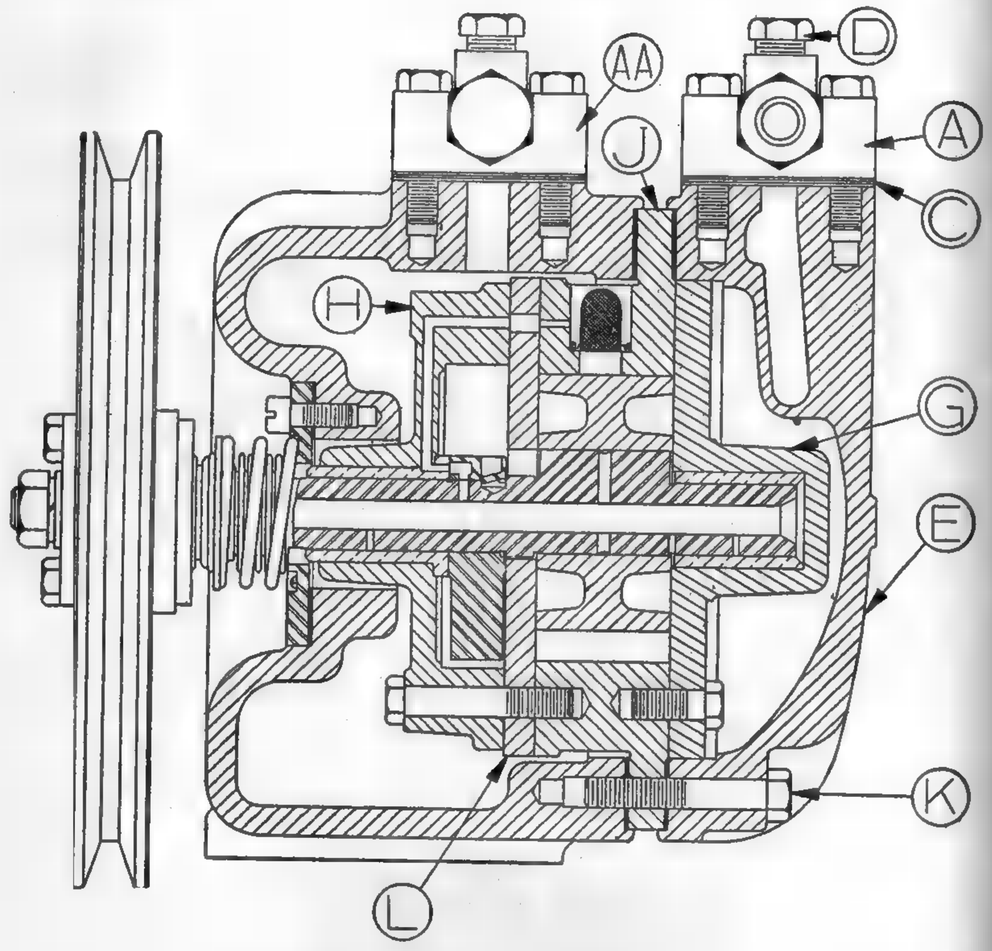


Fig. 363. The Universal compressor
AA. S.S.V.; A. D.S.V.; C. Lead gasket; D. Gage plug; E. Housing; G. and H. End plates
(Courtesy of: Landers, Frary and Clark Co.)

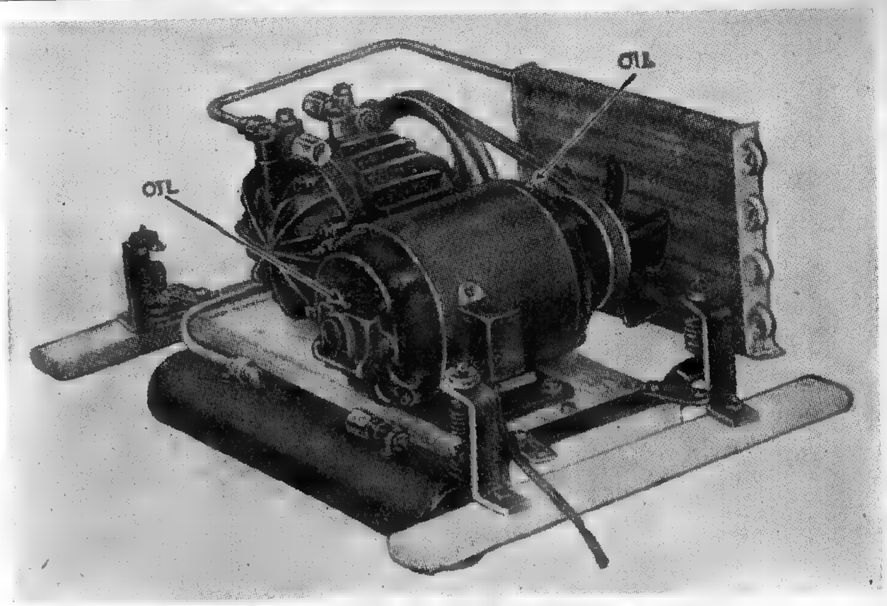


Fig. 364. The Universal condensing unit
(Courtesy of: Landers, Frary and Clark Co.)

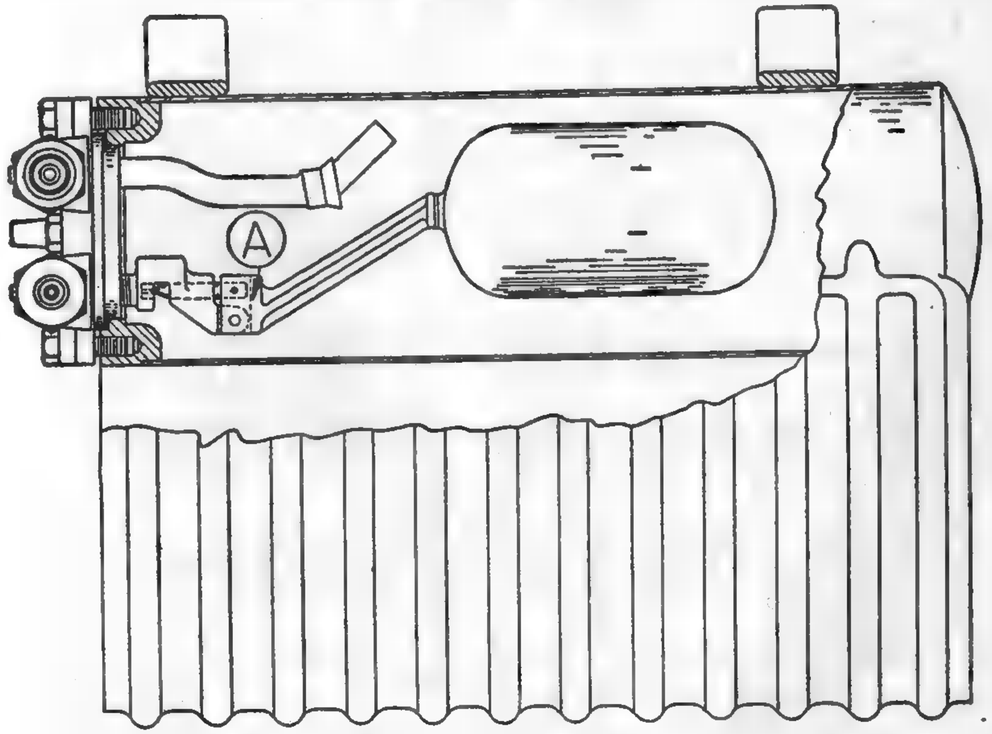


Fig. 365. The Universal cooling coil. "A" is the valve mechanism
(Courtesy of: Landers, Frary and Clark Co.)

511. WESTINGHOUSE, Continued

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure	Quantity of Refrigerant	Refrigerant Control	Quantity of Oil	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
1935	D-121	Her.	Recip.	1	D	⅛	SO_2	.....	.....	4½#	H.S.F.	32 oz.	Therm.	.....	Shell	....
	D-122	Her.	Recip.	1	D	⅛	SO_2	.....	.....	4½#	H.S.F.	32 oz.	Therm.	.....	Shell	....
	D-123	Her.	Recip.	1	D	⅛	SO_2	.....	.....	4½#	H.S.F.	32 oz.	Therm.	.....	Shell	....
	DF-123	Her.	Recip.	1	D	⅛	Freon	.....	.....	6#	H.S.F.	32 oz.	Therm.	.....	Shell	....

512. WHITE MOUNTAIN—THE MAINE MANUFACTURING CO., NASHUA, N. H.

1933	P	Con.	Recip.	2	D	...	M. C.	.....	.....	.....	Ex. Va.	.....	Therm.	.....	Tube	....
	M-45	Con.	Recip.	2	D	...	M. C.	.....	.....	.....	Ex. Va.	.....	Therm.	.....	Tube	....

NOTE—High pressure gage is attached to the LRSV rather than to the DSV.

513. ZEROZONE—ZEROZONE REFRIGERATION CO., 1331 HOLDEN AVE., DETROIT, MICH.

	....	Con.	Recip.	...	B	⅛	SO_2	.....	.....	.....	Ex. Va.	.....	Therm.	.....	Brine	....
	SC	Con.	Recip.	1	B	¼	SO_2	.....	.....	3#	Ex. Va.	1½ pt.	Therm.	.....	Brine	....
	TC	Con.	Recip.	2	B	⅛	SO_2	.....	.....	4#	Ex. Va.	2 pt.	Therm.	.....	Brine	....
	B-49	Con.	Recip.	1	B	⅛	SO_2	.....	.....	1#	Ex. Va.	⅝ pt.	Therm.	.....	.....	....
	B-49	Con.	Recip.	1	B	⅛	SO_2	.....	.....	1⅛#	Ex. Va.	⅞ pt.	.....	.....	.....	....
	A	Con.	Recip.	1	B	⅛	SO_2	.....	.....	4¼#	L.S.F.	⅞ pt.	.....	.....	Flooded	....
1935	A-1	Con.	Recip.	1	B	⅛	M. C.	.....	.....	1#	Ex. Va.	¾ pt.	Therm.	.....	Tube	....

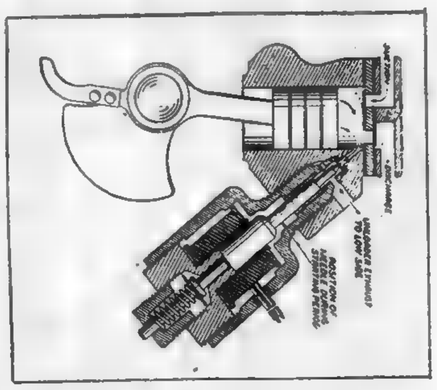


Fig. 867. The Westinghouse solenoid compressor unloader mechanism
(Courtesy of: Westinghouse Electric & Mfg. Company)

514. APEX—APEX ELECTRIC MFG. COMPANY, CLEVELAND, OHIO

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure, Vac.	Quantity of Refrigerant, lbs.	Refrigerant Control	Quantity of Oil, ozs.	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
I.B. 1932-1933	L-140	Con.	Recip.	1	B	1/6	SO_2	.....	8	1.5	Ex. Va.	8	Therm.	.....	Sub.	....
	L-610	Con.	Recip.	1	B	1/6	SO_2	.....	8	1.5	Ex. Va.	8	Therm.	.....	Sub.	....
	L-500	Con.	Recip.	1	B	1/6	SO_2	.....	8	4	L.S.F.	8	Therm.	.....	Flooded	3
	LP-600	Con.	Recip.	1	B	1/6	SO_2	.....	8	4.5	L.S.F.	8	Therm.	.....	Flooded	3
	LP-800	Con.	Recip.	1	B	1/6	SO_2	.....	8	.....	L.S.F.	8	Therm.	.....	Flooded	3
I.B. 1934-1935	.....	.....	.....	...	...	...	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1936	A-430	Con.	Recip.	1	B	1/6	SO_2	.....	5	4	L.S.F.	8	Therm.	.....	Flooded	3
	A-600	Con.	Recip.	1	B	1/6	SO_2	.....	5	5	L.S.F.	8	Therm.	.....	Flooded	3
	A-600T	Con.	Recip.	2	B	1/6	SO_2	.....	5	5	L.S.F.	12	Therm.	.....	Flooded	3
	A-650	Con.	Recip.	1	B	1/6	SO_2	.....	5	5	L.S.F.	8	Therm.	.....	Flooded	3
	A-650T	Con.	Recip	2	B	1/6	SO_2	.....	5	5	L.S.F.	12	Therm.	.....	Flooded	3
	A-785	Con.	Recip.	2	B	1/6	SO_2	.....	5	5.25	L.S.F.	12	Therm.	.....	Flooded	3
1937	B-410	Con.	Recip.	1	B	1/6	SO_2	.....	5	4	L.S.F.	8	Therm.	.....	Flooded	3
	B-625	Con.	Recip.	1	B	1/6	SO_2	.....	5	5.25	L.S.F.	8	Therm.	.....	Flooded	3
	B-625T	Con.	Recip.	2	B	1/6	SO_2	.....	5	5.25	L.S.F.	12	Therm.	.....	Flooded	3
	B-665	Con.	Recip.	2	B	1/6	SO_2	.....	5	5.25	L.S.F.	12	Therm.	.....	Flooded	3
	B-800	Con.	Recip.	2	B	1/6	SO_2	.....	5	5.25	L.S.F.	12	Therm.	.....	Flooded	3
1938	SC-300	Con.	Recip.	1	B	1/6	SO_2	.....	5	4	L.S.F.	■	Therm.	.....	Flooded	3
	SC-400	Con.	Recip.	1	B	1/6	SO_2	.....	5	4	L.S.F.	8	Therm.	.....	Flooded	3
	SC-525	Con.	Recip.	1	B	1/6	SO_2	.....	5	5.25	L.S.F.	8	Therm.	.....	Flooded	3
	SC-525T	Con.	Recip.	2	B	1/6	SO_2	.....	5	5.25	L.S.F.	12	Therm.	.....	Flooded	3
	SC-600	Con.	Recip.	1	B	1/6	SO_2	.....	5	5.25	L.S.F.	8	Therm.	.....	Flooded	3
	SC-600T	Con.	Recip.	2	B	1/6	SO_2	.....	5	5.25	L.S.F.	12	Therm.	.....	Flooded	3
	C-625	Con.	Recip.	1	B	1/6	SO_2	.....	5	5.25	L.S.F.	8	Therm.	.....	Flooded	3
	C-625T	Con.	Recip.	2	B	1/6	SO_2	.....	5	5.25	L.S.F.	12	Therm.	.....	Flooded	3

514. APEX, Continued

	C-710	Con.	Recip.	2	B	1/6	SO_2	.....	■	5.25	L.S.F.	12	Therm.	.....	Flooded	3
	C-800	Con.	Recip.	2	B	1/6	SO_2	.....	5	5.25	L.S.F.	12	Therm.	.....	Flooded	3
	AC-610	Con.	Recip.	1	B	1/6	F-12	.....	8#	1.5	Ex. Va.	12	Therm.	.....	Tube	....
	AC-610T	Con.	Recip.	2	B	1/6	F-12	.....	8#	1.5	Ex. Va.	12	Therm.	.....	Tube	....
	*DC-1	Con.	Recip.	2	B	1/6	F-12	.....	4#	1.5	Ex. Va.	12	Therm.	.....	Tube	....
	*DC-2	Con.	Recip.	2	B	1/6	F-12	.....	4#	1.5	Ex Va.	12	Therm.	.....	Tube	....
	*DC-3	Con.	Recip.	2	B	1/6	F-12	.....	4#	1.5	Ex. Va.	12	Therm.	.....	Tube	....
	AC-710	Con.	Recip.	2	B	1/6	F-12	.....	8#	1.5	Ex. Va.	12	Therm.	.....	Tube	....
	AC-650	Con.	Recip.	1	B	1/6	F-12	.....	8#	1.5	Ex. Va.	12	Therm.	.....	Tube	....
	AC-715	Con.	Recip.	■	B	1/6	F-12	.....	8#	1.5	Ex. Va.	12	Therm.	.....	Tube	....
1939	D-5305	Con.	Recip.	1	B	1/6	SO_2	.....	5"	1.5	Th.E.V.	16	Therm.	.....	Ext.Alu.	....
	D-530T	Con.	Recip.	2	B	1/6	SO_2	.....	5"	1.5	Th.E.V.	16	Therm.	.....	Ext.Alu.	....
	D-620S	Con.	Recip.	1	B	1/6	SO_2	.....	5"	1.5	Th.E.V.	16	Therm.	.....	Ext.Alu.	....
	D-620T	Con.	Recip.	2	B	1/6	SO_2	.....	5"	1.5	Th.E.V.	16	Therm.	.....	Ext.Alu.	....

*These models are a special type having ■ freezer compartment and a high humidity general storage.

515. COLDSPOT—SEARS, ROEBUCK COMPANY, CHICAGO, ILLINOIS

1936	T5	S.H.	Rtry.	...	D	1/6	SO_2	.....	7"	1.9	Ex. Va.	12	Therm.	.....	Tube	....
	W6	S.H.	Rtry.	...	D	1/6	SO_2	.....	7"	1.9	Ex. Va.	12	Therm.	.....	Tube	....
	Y6	S.H.	Rtry.	...	D	1/6	SO_2	.....	7"	1.9	Ex. Va.	12	Therm.	.....	Tube	....
	Z5	S.H.	Rtry.	...	D	1/4	SO_2	.....	7"	1.9	Ex. Va.	12	Therm.	.....	Tube	....
1937	A7	S.H.	Rtry.	...	D	...	.....	3-7	7"	1.75	Ex. Va.	16	Therm.	.....	Tube	....
	A71	S.H.	Rtry.	...	D	...	.....	3-7	7"	1.75	Ex. Va.	16	Therm.	.....	Tube	....
	B7	S.H.	Rtry.	...	D	...	.....	3-7	7"	1.75	Ex. Va.	16	Therm.	.....	Tube	....
	B71	S.H.	Rtry.	...	D	...	.....	3-7	7"	1.75	Ex. Va.	16	Therm.	.....	Tube	....
	BC7	S.H.	Rtry.	...	D	...	.....	3-7	7"	1.75	Ex. Va.	16	Therm.	.....	Tube	....
	BC71	S.H.	Rtry.	...	D	...	.....	3-7	7"	1.75	Ex. Va.	16	Therm.	.....	Tube	....
	C7	S.H.	Rtry.	...	D	...	.....	3-7	7"	1.75	Ex. Va.	16	Therm.	.....	Tube	....
	C72	S.H.	Rtry.	...	D	...	.....	3-7	7"	1.75	Ex. Va.	16	Therm.	.....	Tube	....
	D7	S.H.	Rtry.	...	D	...	.....	3-7	7"	1.75	Ex. Va.	16	Therm.	.....	Tube	....
	E7	S.H	Rtry.	...	D	...	.....	3-7	7"	1.75	Ex. Va.	16	Therm.	.....	Tube	....
	E72	S.H.	Rtry.	...	D	...	.....	3-7	7"	1.75	Ex. Va.	16	Therm.	.....	Tube	....
1938	3874	S.H.	Rtry.	...	D	1/6	SO_2	3 to 7	.....	1¾	Ex. Va.	16	Therm.	.....	Tube	....
	3804	S.H.	Rtry.	...	D	1/6	SO_2	3 to 7	.....	1¾	Ex. Va.	16	Therm.	.....	Tube	....

515. COLDSPOT, Continued

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure, Vac.	Quantity of Refrigerant, lbs.	Refrigerant Control	Quantity of Oil, ozs.	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
	3806	S.H.	Rtry.	...	D	⅛	SO_2	3 to 7	.....	1¾	Ex. Va.	16	Therm.	.....	Tube	....
	3836	S.H.	Rtry.	...	D	⅛	SO_2	3 to 7	.....	1¾	Ex. Va.	16	Therm.	.....	Tube	....
	3816	S.H.	Rtry.	...	D	⅛	SO_2	3 to 7	.....	1¾	Ex. Va.	16	Therm.	.....	Tube	....
	3838	S.H.	Rtry.	...	D	⅛	SO_2	3 to 7	.....	1¾	Ex. Va.	16	Therm.	.....	Tube	....
	3818	S.H.	Rtry.	...	D	⅛	SO_2	3 to 7	.....	1¾	Ex. Va.	16	Therm.	.....	Tube	....
1939	3954	S.H.	Rtry.	...	D	⅛	SO_2	3 to 7	.....	1¾	Ex. Va.	16	Therm.	.....	Tube	....
	3956	S.H.	Rtry.	...	D	⅛	SO_2	3 to 7	.....	1¾	Ex. Va.	16	Therm.	.....	Tube	....
	3976	S.H	Rtry.	...	D	⅛	SO_2	3 to 7	.....	1¾	Ex. Va.	16	Therm.	.....	Tube	....
	3996	S.H.	Rtry.	...	D	⅛	SO_2	3 to 7	.....	1¾	Ex. Va.	16	Therm.	.....	Tube	....
	3936	S.H.	Rtry.	...	D	⅛	SO_2	3 to 7	.....	1¾	Ex. Va.	16	Therm.	.....	Tube	....
	3938	S.H.	Rtry.	...	D	⅛	SO_2	3 to 7	.....	1¾	Ex. Va.	16	Therm.	.....	Tube	....

516. COPELAND—COPELAND REFRIGERATION CORPORATION, SIDNEY, O.

1936	C2-16	Con.	Recip.	2	B	⅛	M. C.	.....	5#	1	Ex. Va.	14	Therm.	.....	Porc.	....
1937	C2-16	Con.	Recip.	2	B	⅛	M. C.	.....	5	1	Ex. Va.	14	Therm.	.....	.....	....
	C2-20	Con.	Recip.	2	B	⅛	M. C.	.....	5	1	Ex. Va.	14	Therm.	.....	.....	....
1938	C2-16	Con.	Recip.	2	B	⅛	M. C.	.....	5	1	Ex. Va.	14	Therm.	.....	Copper	....
	C2-20	Con.	Recip.	2	B	⅛	M. C.	.....	5	1	Ex. Va.	14	Therm.	.....	Copper	....
1939	C2-16	Con.	Recip.	2	B	⅛	M. C.	.....	5	1	Ex. Va.	14	Therm.	.....	Copper	....
	C2-20	Con.	Recip.	2	B	⅛	M. C.	.....	5	1	Ex. Va.	14	Therm.	.....	Copper	....

517. CROSLEY—THE CROSLEY RADIO CORPORATION, CINCINNATI, OHIO

1936	T-1	Her.	Recip.	1	D	⅛	SO_2	.....	.....	34t-37 oz.	Cap. T.	25	Therm.	.....	Steel	....
	T-2	Her	Recip.	1	D	.15	F-12	.....	.....	37	Cap. T.	25	Therm.	.....	Steel	....

	Q-3	Con.	Recip.	1	B	⅛	SO_2	.....	.....	28-34	Cap. T.	10	Therm.	.....	Steel	....
1937	T-1	Her.	Recip.	1	D	⅛	SO_2	.....	.....	17-29	Cap. T.	34	Therm.	.....	Steel	....
	T-5	Her.	.....	1	D	⅛	F-12	.....	.....	31-37	Fl. Valve	25	Therm.	.....	Steel	....
	Q-1	Recip.	.....	1	B	⅛	SO_2	.....	.....	28	Cap. T.	10	Therm.	.....	Steel	....
	and Q-3	Recip.	.....	1	B	⅛	SO_2	.....	.....	15	Cap. T.	10	Therm.	.....	Steel	....
1938	....	Her.	Recip.	1	D	...	.....	.....	.....	.....	.....	.....	Therm.	.....	Steel	....
	T-5	Her.	.....	1	D	⅛	F-12	.....	.....	30-32	Fl Valve	25	Therm.	.....	Steel	....
	Q-1	Recip.	.....	1	B	⅛	SO_2	.....	.....	28	Cap. T.	10	Therm.	.....	Steel	....
	Q-3	Recip.	.....	1	B	⅛	SO_2	.....	.....	16	.....	10	Therm.	.....	Steel	....
1939	T-5	Her.	Recip.	1	D	⅛	F-12	.....	.....	24-25	.....	25	Therm.	.....	Steel	....
	T-9	Her.	Recip.	1	D	1/10	F-12	.....	.....	23	Cap. T.	48	Therm.	.....	Steel	....
	Q-1	Con.	Recip.	1	B	⅛	SO_2	.....	.....	15-16	Cap. T.	10	Therm.	.....	Steel	....
	Q-7	Con.	Recip.	1	B	⅛	SO_2	.....	.....	15	Cap. T.	10	Therm.	.....	Steel	....

518. DAYTON — DAYTON REFRIGERATOR CORPORATION, BUFFALO, NEW YORK (HEINZ & MUNSCHAUER)

1936	500A	Con.	Recip.	1	B	⅛	SO_2	.....	8"	3½-S	L.S.F.	14	Therm.	.....	Porc.	....
	500A	Con.	Recip.	1	B	¼	SO_2	.....	8"	1½	Ex. Va.	14	Therm.	.....	Tube	....
1937	500A	Con.	Recip.	1	B	⅛	SO_2	.....	8"	3½-S	L.S.F.	14	Therm.	.....	Porc.	....
	500A	Con.	Recip.	1	B	¼	SO_2	.....	8"	1½	Ex. Va.	14	Therm.	.....	Tube	....
1938	500A	Con.	Recip.	1	B	⅛	SO_2	.....	5-8"	1½	Ex. Va.	14	Therm.	.....	.....	....
	1000A	Con.	Recip.	2	B	⅛	SO_2	.....	5-8"	1½	Ex. Va.	20	Therm.	.....	.....	....
	588L	Her.	Recip.	1	D	⅛	F-12	.....	12-15#	1¼	Cap. T.	.....	Therm.	.....	Shell	....
1939	500A	Con.	Recip.	1	B	⅛	SO_2	.....	5-8"	1½	Ex. Va.	14	Therm.	.....	Tube	....
	1000A	Con.	Recip.	2	B	⅛	SO_2	.....	5-8"	1½	Ex. Va.	20	Therm.	.....	Tube	....
	588L	Her.	Recip.	1	D	⅛	F-12	.....	12-15#	1¼	Cap. T.	.....	Therm.	.....	Shell	....
	C54L	Her.	Recip.	1	D	⅛	F-12	.....	12-15#	1¼	Cap. T.	.....	Therm.	.....	Shell	....
	C48L	Her.	Recip.	1	D	⅛	F-12	.....	12-15#	1¼	Cap. T.	.....	Therm.	.....	Shell	....
	C34L	Her.	Recip.	1	D	⅛	F-12	.....	12-15#	1¼	Cap. T.	.....	Therm.	.....	Shell	....

519. GALE & WHITEHALL—GALE PRODUCTS, GALESBURG, ILLINOIS

Year	Model	Design	Compressor	Cylinder	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure, Vac.	Quantity of Refrigerant, lbs.	Refrigerant Control	Quantity of Oil, ozs.	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
1937	.....	Con.	Recip.	1	B	⅙	SO_2	.....	.....	25 oz.	Th. E. V.	16	Therm.	.....	Tube	....
	.....	Con.	Recip.	2	B	⅙	SO_2	.....	.....	25	Th. E. V.	16	Therm.	.....	Tube	....
1938	.....	Con.	Recip.	1	B	⅙	SO_2	.....	.....	25	Th. E. V.	16	Therm.	.....	Tube	....
	.....	Con.	Recip.	2	B	⅙	SO_2	.....	.....	25	Th. E. V.	16	Therm.	.....	Tube	....
1939	.....	Con.	Recip.	1	B	⅙	SO_2	.....	.....	25	Th. E. V.	16	Therm.	.....	Tube	....
	.....	Con.	Recip.	2	B	⅙	SO_2	.....	.....	25	Th. E. V.	16	Therm.	.....	Tube	....

520. GENERAL ELECTRIC—GENERAL ELECTRIC CO., CLEVELAND, OHIO

1935	LK-1, 2	Her.	Recip.	1	D	⅛	SO_2	5	0	1.4	H.S.F.	4 Pints	Therm.	.....	St. Steel	....
	DK-1	Her.	Recip.	1	D	⅛	SO_2	6	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	CG-1	Her.	Recip.	1	D	⅛	SO_2	6	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	CF-1	Her.	Recip.	1	D	⅛	SO_2	6	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	CK-1	Her.	Recip.	1	D	⅛	SO_2	6	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	CF-2	Her.	Recip.	1	D	⅛	SO_2	8	0	2.0	H.S.F.	4	Therm.	.....	St. Steel	....
	CK-2	Her.	Recip.	1	D	⅛	SO_2	8	0	2.25	H.S.F.	4	Therm.	.....	St. Steel	....
	CK-30	Her.	Recip.	1	D	⅛	SO_2	13	0	2.7	H.S.F.	5.2	Therm.	.....	St. Steel	....
	CK-35	Her.	Recip.	1	D	⅛	SO_2	13	0	4.0	H.S.F.	5.2	Therm.	.....	St. Steel	....
1936	LK-1, 2	Her.	Recip.	1	D	⅛	SO_2	5	0	1.4	H.S.F.	4	Therm.	.....	St. Steel	....
	CG-1	Her.	Recip.	1	D	⅛	SO_2	6	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	DK-1	Her.	Recip.	1	D	⅛	SO_2	6	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	CF-1	Her.	Recip.	1	D	⅛	SO_2	4	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	CK-1	Her.	Recip.	1	D	⅛	SO_2	4	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	CF-2	Her.	Recip.	1	D	⅛	SO_2	6	0	2.0	H.S.F.	4	Therm.	.....	St. Steel	....
	CK-15	Her.	Recip.	1	D	⅛	SO_2	4	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	CK-2	Her.	Recip.	1	D	⅛	SO_2	6	0	2.25	H.S.F.	4	Therm.	.....	St. Steel	....
	CK-30	Her.	Recip.	1	D	⅛	SO_2	10	0	2.7	H.S.F.	5.2	Therm.	.....	St. Steel	....

520. GENERAL ELECTRIC, Continued

	CK-35	Her.	Recip.	1	D	⅛	SO_2	10	0	4.0	H.S.F.	5.2	Therm.	.....	St. Steel	....
1937	LK-1, 2	Her.	Recip.	1	D	⅛	SO_2	5	0	1.4	H.S.F.	4	Therm.	.....	St. Steel	....
	CH-1	Her.*	Recip.	1	D	⅛	SO_2	[illegible]	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	CJ-1	Her.	Recip.	1	D	⅛	SO_2	[illegible]	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	CF-1	Her.	Recip.	1	D	⅛	SO_2	4	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	CF-2	Her.	Recip.	1	D	⅛	SO_2	6	0	2.0	H.S.F.	4	Therm.	.....	St. Steel	....
	CK-26	Her.	Recip.	1	D	⅛	SO_2	6	0	2.25	H.S.F.	4	Therm.	.....	St. Steel	....
	CK-28	Her.	Recip.	1	D	⅛	SO_2	6	0	2.25	H.S.F.	4	Therm.	.....	St. Steel	....
	CE-34M	Her.*	Recip.	1	D	⅛	SO_2	8	0	3.75	H.S.F.	4.2	Therm.	.....	St. Steel	....
1938	LK-2	Her.	Recip.	1	D	⅛	SO_2	5	0	1.4	H.S.F.	4	Therm.	.....	St. Steel	....
	CH-1	Her.*	Recip.	1	D	⅛	SO_2	8	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	CJ-1	Her.	Recip.	1	D	⅛	SO_2	8	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	CE-140	Her.*	Recip	1	D	⅛	SO_2	8	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	CF-1	Her.	Recip.	1	D	⅛	SO_2	4	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	CF-2	Her.	Recip.	1	D	⅛	SO_2	6	0	2.0	H.S.F.	4	Therm.	.....	St. Steel	....
	CK-26	Her.	Recip.	1	D	⅛	SO_2	6	0	2.25	H.S.F.	4	Therm.	.....	St. Steel	....
	CF-28	Her.	Recip.	1	D	⅛	SO_2	6	0	2.0	H.S.F.	4	Therm.	.....	St. Steel	....
	CK-28	Her.	Recip.	1	D	⅛	SO_2	6	0	2.25	H.S.F.	4	Therm.	.....	St. Steel	....
	CE-34A	Her.*	Recip.	1	D	⅛	F-12	8	16	4.75	H.S.F.	4.2	Therm.	.....	St. Steel	....
1939	CH-1	Her.*	Recip.	1	D	⅛	SO_2	8	0	1.75	H.S.F.	4	Therm	.....	St. Steel	....
	CJ-1	Her.	Recip.	1	D	⅛	SO_2	8	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	CE-140	Her.*	Recip.	1	D	⅛	SO_2	8	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	CF-1	Her.	Recip.	1	D	⅛	SO_2	4	0	1.75	H.S.F.	4	Therm.	.....	St. Steel	....
	CF-2	Her.	Recip.	1	D	⅛	SO_2	6	0	2.0	H.S.F.	4	Therm.	.....	St. Steel	....
	CF-28	Her.	Recip.	1	D	⅛	SO_2	6	0	2.0	H.S.F.	4	Therm.	.....	St. Steel	....
	CE-34B	Her.*	Recip	1	D	⅙	F-12	[illegible]	16	4.75	H.S.F.	4.2	Therm.	.....	St. Steel	....

*Equipped with external fan motor.

521. GIBSON—GIBSON ELECTRIC REFRIGERATOR CORPORATION, GREENVILLE, MICHIGAN

1936	H6	Her.	Recip.	2	D	⅛	SO_2	5#	5″	41-56 oz.	H.S.F.	16	Therm.	.....	Plate & Tube	....
1937	H7	Her.	Recip.	2	D	⅛	SO_2	5#	5″	41-56	H.S.F.	16	Therm.	.....	Plate & Tube	....
1938	H8	Her.	Recip.	2	D	⅛	SO_2	5#	5″	41-56	H.S.F.	16	Therm.	.....	Plate & Tube	....

521. GIBSON, Continued

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure, Vac.	Quantity of Refrigerant, oz.	Refrigerant Control	Quantity of Oil, ozs.	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
	HF88	Her.	Recip.	1	D	⅛	F-12	.....	.....	16 oz.	Cap. T.	16	Therm.	.....	Plate & Tube	....
1939	H9	.....	Recip.	2	D	⅛	SO_2	5#	5	21-56	H.S.F.	16	Therm.	.....	Plate & Tube	....
	AHF89	Her.	Recip.	1	D	⅛	F-12	16	12-15	10-12	Cap T.	16	Therm.	.....	Plate & Tube	....
	HF89	Her.	Recip.	1	D	⅛	F-12	16	12-15	10-12	Cap. T.	16	Therm.	.....	Plate & Tube	....
	SCF9	Con.	Recip.	...	B	⅛	F-12	17	12-15	10-12	Cap. T.	10	Therm.	.....	Plate & Tube	....

522. GILFILLAN—GILFILLAN BROS., INC., 1815 VENICE BLVD., LOS ANGELES, CALIFORNIA

1936	D	Con.	Recip.	2	B	⅛	SO_2	14	8-12"	3½#	Ex. Va.	12	Therm.	.....	Tube	....
	E	Con.	Recip.	2	B	⅛	SO_2	14	8-12"	3½	Ex. Va.	12	Therm.	.....	Tube	....
1937	E	Con.	Recip.	2	B	⅛	SO_2	14	8-12"	3½	Th. E. V.	12	Therm.	.....	Tube	....
	F	Con.	Recip.	2	B	⅛	SO_2	14	8-12"	3½	.....	.....	.....	.....	Tube	....
	G	.....	.....	2	B	⅛	.....	.....	8-12"	.....	.....	.....	.....	.....	.....	....
1938	F	Con.	Recip.	2	B	⅛	SO_2	14	.....	3½	Th. E. V.	12	Therm.	.....	Tube	....
	G	Con.	Recip.	2	B	⅛	.....	.....	8-12"	.....	.....	.....	.....	.....	.....	....
1939	F	Con.	Recip.	2	B	⅛	SO_2	14	.....	3½	Th. E. V.	12	Therm.	.....	Tube	....
	G	Con.	Recip.	2	B	⅛	SO_2	14	8-12"	3½	Th. E. V.	12	.....	.....	.....	....

1937, 1938, 1939 Models Must Turn Contra Clockwise As One Faces the Back of Compressor.
All compressors are of the horizontal type.

523. HOSTESS—HOSTESS CORPORATION LTD., TORONTO, ONTARIO, CANADA

												Imp. Gal.				
1936	.....	Con.	Recip.	2	B	⅛	SO_2	.....	.....	1⅛#	Ex. Va.	⅛	Therm.	.....	Tube	....
	.....	Her.	Rtry.	...	D	⅛	SO_2	.....	.....	3¼	H.S.F.	⅛	Therm.	.....	Shell	....
	.....	Her.	Rtry.	...	D	⅛	SO_2	.....	.....	3¾	H.S.F.	⅛	Therm.	.....	Shell	....
1937	.....	Her.	Rtry.	...	D	⅛	SO_2	.....	.....	3¾	H.S.F.	⅛	Therm.	.....	Shell	....

524. HOTPOINT—EDISON G. E. APPLIANCE CO., INC., CHICAGO, ILLINOIS

1938	CE	Her.	Recip.	1	D	...	SO_2	.....	.....	.....	H.S.F.	.....	Therm.	.....	S.S.	....
1939	CE-34	Her.	Recip.	1	D	⅛	F-12	.....	.....	4.75#	H.S.F.	68	Therm.	.....	S.S.	....
	CE-1	Her.	Recip.	1	D	⅛	SO_2	.....	.....	1.75	H.S.F.	64	Therm.	.....	S.S.	....
	CE-2	Her.	Recip.	1	D	⅛	SO_2	.....	.....	2.00	H.S.F.	64	Therm.	.....	S.S.	....
	CE-28	Her.	Recip.	1	D	⅛	SO_2	.....	.....	2.00	H.S.F.	64	Therm.	.....	S.S.	....
	CH-1C	Her.	Recip.	1	D	⅛	SO_2	.....	.....	1.75	H.S.F.	64	Therm.	.....	S.S.	....
	CE-14	Her.	Recip.	1	D	⅛	SO_2	.....	.....	1.75	H.S.F.	64	Therm.	.....	S.S.	....

525. JEWETT — JEWETT REFRIGERATION COMPANY, INC., BUFFALO, NEW YORK

1939	80	Con.	Recip.	2	B	⅛	M. S.	*	.....	1¼#	Th. E. V.	20	Therm.	.....	Tube	....

*This unit has ■ dual cabinet, one part for keeping moist foods and one part for general refrigeration.

526. KELVINATOR—KELVINATOR CORPORATION, DETROIT, MICHIGAN

1936	A9116	Con.	Recip.	1	B	⅛	SO_2	16	.....	24-35 oz.	H.S.F.	19	Therm.	.....	Shell	....
	B9116	Con.	Recip.	2	B	⅛	SO_2	16-18	.....	31-36	H.S.F.	26	Therm.	.....	Shell	....
	B9125	Con.	Recip.	2	B	¼	SO_2	18	.....	31-44	H.S.F.	18	Therm.	.....	Shell	....
1937	A9116	Con.	Recip.	1	B	⅛	SO_2	16	.....	14-18	H.S.F.	19	Therm.	.....	Shell	....
	B9116	Con.	Recip.	2	B	⅛	SO_2	16-18	.....	18-31	H.S.F.	26	Therm.	.....	Shell	....
	B9125	Con.	Recip.	2	B	¼	SO_2	18	.....	31-44	H.S.F.	18	Therm.	.....	Shell	....
1938	63001	Her.	Recip.	1	D	...	F-12	12-24	.....	21-25	H.S.F.	35	Therm.	.....	Shell	....

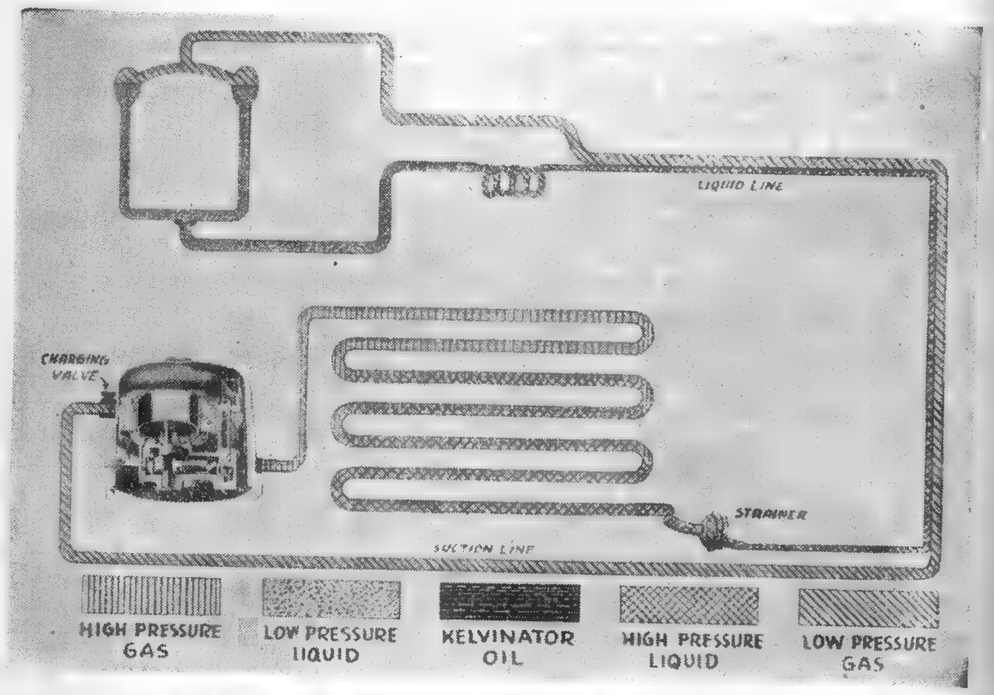


Fig. 368. The Kelvinator 1939 Refrigerating Cycle
(Courtesy of: Kelvinator Corporation)

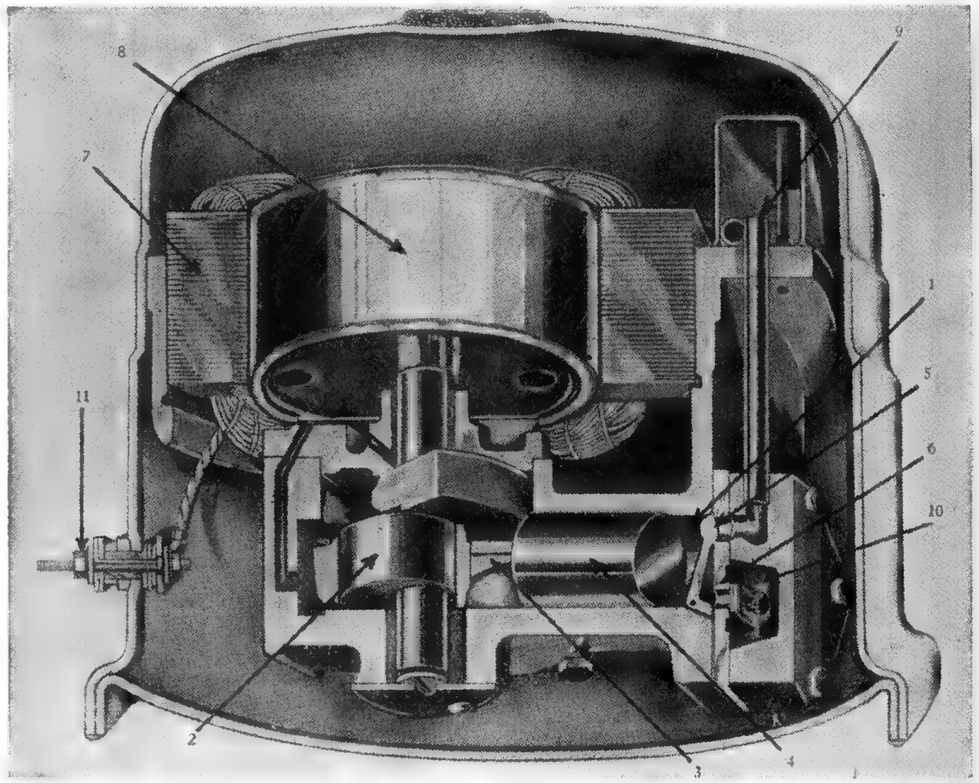


Fig. 369. The Kelvinator 1939 Compressor. 1. Compressor cylinder; 2. Compressor eccentric; 3. Connecting rod; 4. Compressor piston; 5. Suction valve; 6. Discharge valve; 7. Motor stator; 8. Rotor; 9. Suction intake; 10. Discharge port
(Courtesy of: Kelvinator Corporation)

526. KELVINATOR, Continued

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure, lbs.	Quantity of Refrigerant, ozs.	Refrigerant Control	Quantity of Oil, ozs.	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
	B9125	Con.	Recip.	2	B	¼	SO_2	18	.....	31-44	H.S.F.	18	Therm.	.....	Shell	....
	SA9516	Con.	Recip.	1	B	⅛	F-12	.....	7-9	17-19	H.S.F.	12	Therm.	.....	Shell	
	SB9516	Con.	Recip.	1	B	⅛	F-12	.....	7-9	19-21	H.S.F.	18	Therm.	.....	Shell	....
1939	154010	Her.	Recip.	1	D	⅛	F-12	12 to 14	.....	13	Cap. T.	18	Therm.	.....	Shell	....
	154011	Her.	Recip.	1	D	⅛	F-12	12 to 14	.....	14	Cap. T.	18	Therm.	.....	Shell	....
	154012	Her.	Recip.	1	D	⅛	F-12	12 to 14	.....	15	Cap. T.	18	Therm.	.....	Shell	....

527. LEONARD—LEONARD REFRIGERATOR CORPORATION, DETROIT, MICHIGAN

1936	Sa	Con.	Recip.	1	B	⅛	F-12	.....	.....	22-28	H.S.F.	15	Therm.	.....	Porc.	....
	B	Con.	Recip.	2	B	¼	F-12	.....	.....	48	H.S.F.	24	Therm.	.....	Porc.	....
	L7-36	Con.	Recip.	1	B	⅛	F-12	.....	.....	30	H.S.F.	15	Therm.	.....	Porc.	....
	P7-36	Con.	Recip.	1	B	⅛	F-12	.....	.....	30	H.S.F.	15	Therm.	.....	Porc.	....
1937	SA	Con.	Recip.	1	B	⅛	F-12	.....	.....	22-30	H.S.F.	15	Therm.	.....	Porc.	....
	B	Con.	Recip.	2	B	¼	F-12	.....	.....	48	H.S.F.	24	Therm.	.....	Porc.	....
1938	SA	Con.	Recip.	1	B	⅛	F-12	.....	.....	22-30	H.S.F.	15	Therm.	.....	Porc.	....
	B	Con.	Recip.	2	B	¼	F-12	.....	.....	48	H.S.F.	24	Therm.	.....	Porc.	....
	154510	Her.	Recip.	1	D	...	F-12	.....	.....	14	Cap. T.	.....	Therm.	.....	S.S.	....
	154511	Her.	Recip.	1	D	...	F-12	.....	.....	15	Cap. T.	.....	Therm.	.....	S.S.	....
	154513	Her.	Recip.	1	D	...	F-12	.....	.....	13	Cap. T.	.....	Therm.	.....	S.S.	....
	.....	Her.	Recip.	1	D	...	F-12	.....	.....	.....	.....	.....	Therm.	.....	.....	....
1939	Sa	Con.	Recip.	1	B	⅛	F-12	.....	6	13	H.S.F.	12	Therm.	.....	S.S.	....
	.....	Con.	Recip.	1	B	⅙	F-12	.....	6	23	H.S.F.	12	Therm.	.....	S.S.	....

528. MAYFLOWER—TRUPAR MFG. CO., SIDNEY, OHIO

1936	TL-70	Con.	Recip.	1	B	⅙	SO_2	.....	.....	4-5 lbs.	L.S.F.	18	Therm.	.....	Porc.	....
	TL-140	Con.	Recip.	2	B	¼	SO_2	.....	.....	4-5	L.S.F.	18	Therm.	.....	Porc.	....
1937	.....	Con.	Recip.	1	B	⅙	SO_2	.....	.....	4-5	L.S.F.	18	Therm.	.....	Porc.	....
	.....	Con.	Recip.	2	B	¼	SO_2	.....	.....	4-5	L.S.F.	18	Therm.	.....	Porc.	....
1938	.....	Con.	Recip.	1	B	⅙	SO_2	.....	.....	4-5	L.S.F.	18	Therm.	.....	Porc.	....
	.....	Con.	Recip.	2	B	¼	SO_2	.....	.....	4-5	L.S.F.	18	Therm.	.....	Porc.	....

529. NORGE—NORGE DIVISION, BORG-WARNER CORPORATION, DETROIT, MICHIGAN

								Ave Sleeve Temp.								
								Cut-In	Cut-Out							
1936	S-31-6	Con.	Rtry.	...	B	⅙	SO_2	23°	9°	5¼ lbs.	L.S.F.	32-33	Therm.	.....	Flooded	....
	E-32-6	Con.	Rtry.	...	B	⅙	SO_2	23	9	5¼	L.S.F.	32-33	Therm.	.....	Flooded	....
	E-42-6	Con.	Rtry.	...	B	⅙	SO_2	23	9	5¼	L.S.F.	32-33	Therm.	.....	Flooded	....
	E-52-6	Con.	Rtry.	...	B	⅙	SO_2	23	9	5½	L.S.F.	32-33	Therm.	.....	Flooded	....
	E-62-6	Con.	Rtry.	...	B	⅙	SO_2	23	9	5½	L.S.F.	32-33	Therm.	.....	Flooded	....
	E-62-6B	Con.	Rtry.	...	B	⅙	SO_2	23	9	5½	L.S.F.	32-33	Therm.	.....	Flooded	....
	L-42-6	Con.	Rtry.	...	B	⅙	SO_2	23	9	5¼	L.S.F.	32-33	Therm.	.....	Flooded	....
	P-42-6	Con.	Rtry.	...	B	⅙	SO_2	23	9	5¼	L.S.F.	32-33	Therm.	.....	Flooded	....
	L-52-6	Con.	Rtry.	...	B	⅙	SO_2	23	9	5½	L.S.F.	32-33	Therm	.....	Flooded	....
	P-52-6	Con.	Rtry.	...	B	⅙	SO_2	23	9	5½	L.S.F.	32-33	Therm.	.....	Flooded	....
	L-62-6	Con.	Rtry.	...	B	⅙	SO_2	23	9	5½	L.S.F.	32-33	Therm.	.....	Flooded	....
	P-62-6	Con.	Rtry.	...	B	⅙	SO_2	23	9	5½	L.S.F.	32-33	Therm.	.....	Flooded	....
	L-72-6	Con.	Rtry.	...	B	⅙	SO_2	23	[illegible]	5¾	L.S.F.	32-33	Therm.	.....	Flooded	....
	P-72-6	Con.	Rtry.	...	B	⅙	SO_2	23	9	5¾	L.S.F.	32-33	Therm.	.....	Flooded	....
	L-82-6	Con.	Rtry.	...	B	¼	SO_2	23	9	6	L.S.F.	32-33	Therm.	.....	Flooded	....
	P-82-6	Con.	Rtry.	...	B	¼	SO_2	23	9	6	L.S.F.	32-33	Therm.	.....	Flooded	....
	P-95-6	Con.	Rtry.	...	B	¼	SO_2	25	10	6	L.S.F.	32-33	Therm.	.....	Flooded	....
	P-112-6	Con.	Rtry.	...	B	¼	SO_2	25	10	10	L.S.F.	34-36	Therm.	.....	Flooded	....
	LTL-62-6	Con.	Rtry.	...	B	⅙	SO_2	.....	.....	6	L.S.F.	32-33	Therm.	.....	Flooded	....
	LTP-62-6	Con.	Rtry.	...	B	⅙	SO_2	.....	.....	6	L.S.F.	32-33	Therm.	.....	Flooded	....
	LTP-82-6	Con.	Rtry.	...	B	¼	SO_2	.....	.....	6	L.S.F.	32-33	Therm.	.....	Flooded	....
	GL-75-6	Con.	Rtry.	...	B	⅙	SO_2	.....	.....	5	L.S.F.	32-33	Therm.	.....	Flooded	....
1937	S-31-37	Con.	Rtry.	...	B	⅙	SO_2	24	16	5	L.S.F.	26-27	Therm.	.....	Flooded	....

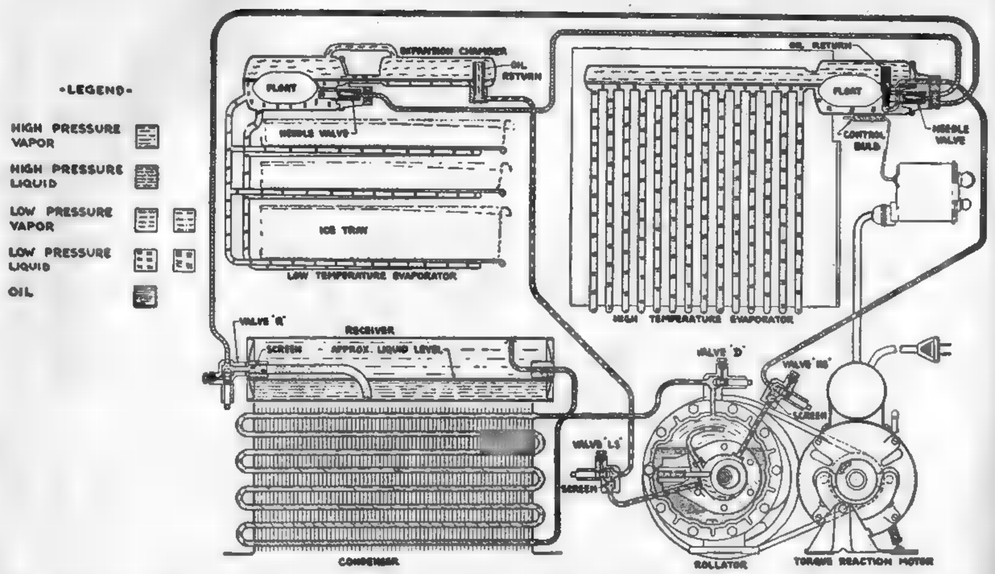


Fig. 370. The Norge low temperature and regular temperature unit cycle diagram
(Courtesy of: Norge Corporation)

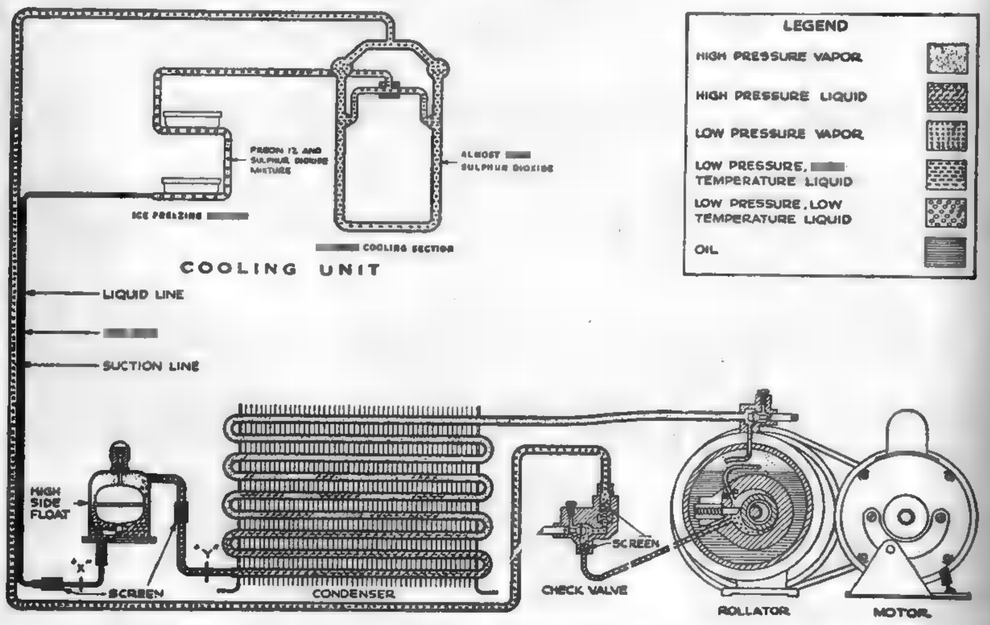


Fig. 371. The Norge C/M synchronizer unit cycle diagram
(Courtesy of: Norge Corporation)

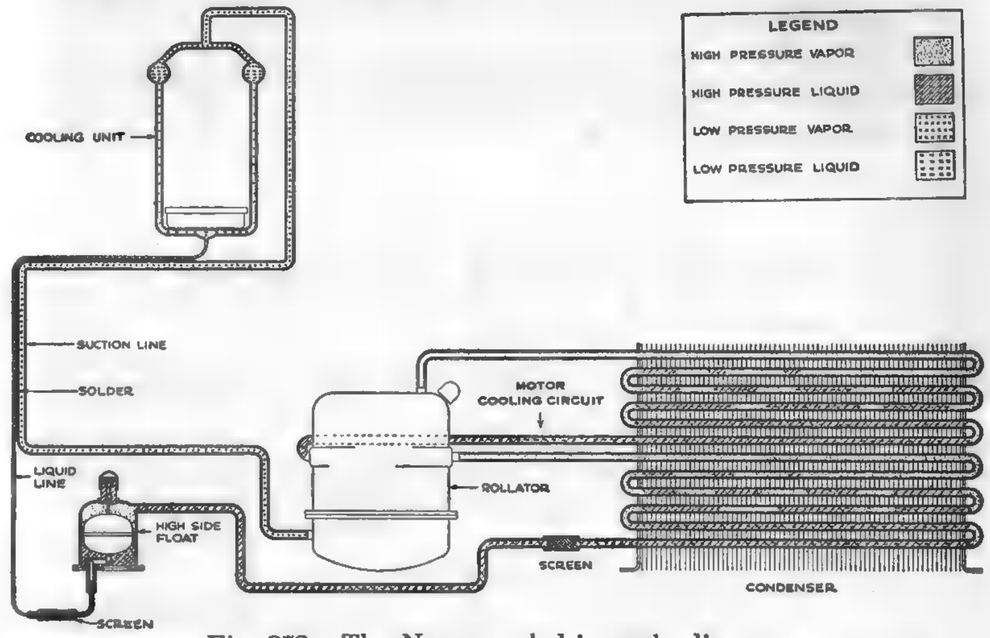


Fig. 372. The Norge sealed-in cycle diagram
(Courtesy of: Norge Corporation)

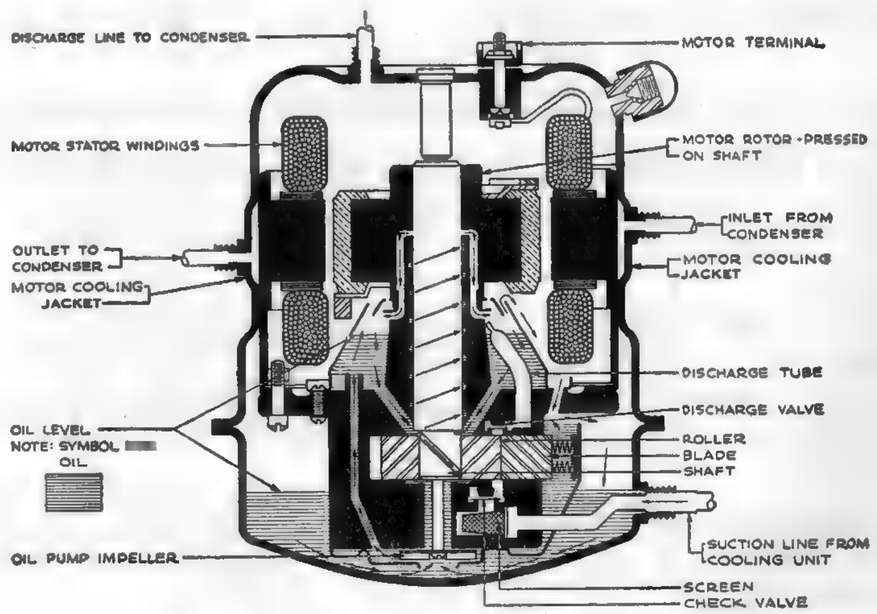


Fig. 373. The Norge sealed-in system rollator
(Courtesy of: Norge Corporation)

529. NORGE, Continued

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Average Sleeve Temp. Cut-In	Average Sleeve Temp. Cut-Out	Quantity of SO_2 Refrigerant, lbs.	Refrigerant Control	Quantity of Oil, ozs.	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
	S-32-37	Con.	Rtry.	...	B	1/6	SO_2	24	16	5	L.S.F.	26-27	Therm.	.....	Flooded	....
	S-42-37	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¼	L.S.F.	26-27	Therm.	.....	Flooded	....
	S-52-37	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¼	L.S.F.	26-27	Therm.	.....	Flooded	....
	S-62-37	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¼	L.S.F.	26-27	Therm.	.....	Flooded	....
	S-72-37	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¾	L.S.F.	26-27	Therm.	.....	Flooded	....
	P-42-37	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¼	L.S.F.	26-27	Therm.	.....	Flooded	....
	N-52-37	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¼	L.S.F.	26-27	Therm.	.....	Flooded	....
	P-52-37	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¼	L.S.F.	26-27	Therm.	.....	Flooded	....
	N-61-37	Con	Rtry.	...	B	1/6	SO_2	24	16	5¼	L.S.F	26-27	Therm.	.....	Flooded	....
	P-61-37	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¼	L.S.F.	26-27	Therm.	.....	Flooded	....
	N-72-37	Con	Rtry.	...	B	1/6	SO_2	24	16	5¾	L.S.F.	26-27	Therm.	.....	Flooded	....
	P-72-37	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¾	L.S.F.	26-27	Therm.	.....	Flooded	....
	N-81-37	Con.	Rtry.	...	B	¼	SO_2	24	16	5¾	L.S.F.	26-27	Therm.	.....	Flooded	....
	P-81-37	Con.	Rtry.	...	B	¼	SO_2	24	16	5¾	L.S.F.	26-27	Therm.	.....	Flooded	....
	LTP-81-37	Con.	Rtry.	...	B	¼	SO_2	.....	.....	6	L.S.F.	26-27	Therm.	.....	Flooded	....
	LTP-122-37	Con.	Rtry.	...	B	¼	SO_2	.....	.....	10	L.S.F.	32-33	Therm.	.....	Flooded	....
	GN-75-37	Con.	Rtry.	...	B	1/6	SO_2	.....	.....	5	L.S.F.	26-27	Therm.	.....	Flooded	....
	NF-75-37	Con.	Rtry.	...	B	1/6	SO_2	.....	.....	5	L.S.F.	26-27	Therm.	.....	Flooded	....
1938	A-31-8	Con.	Rtry.	...	B	1/6	SO_2	24	16	5 *3½	L.S.F.	26-27	Therm.	.....	Flooded	....
	R-32-8	Con.	Rtry.	...	B	1/6	SO_2	24	16	5 *3½	L.S.F.	26-27	Therm.	.....	Flooded	....
	R-41-8	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¼	L.S.F.	26-27	Therm.	.....	Flooded	....
	R-41-8A	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¼ *3¾	L.S.F.	26-27	Therm.	.....	Flooded	....
	S-52-8	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¼ *3¾	L.S.F.	26-27	Therm.	.....	Flooded	....
	S-62-8	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¼ *3¾	L.S.F.	26-27	Therm.	.....	Flooded	....
	S-72-37A	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¾ *4¼	L.S.F.	26-27	Therm.	.....	Flooded	....
	S-71-8	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¾ *4¼	L.S.F.	26-27	Therm.	.....	Flooded	....
	S-71-8A	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¾	L.S.F.	26-27	Therm.	.....	Flooded	....
	R-42-8	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¼ *3¾	L.S.F.	26-27	Therm.	.....	Flooded	....

529. NORGE, Continued

	P-42-8	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¼ *3¾	L.S.F.	26-27	Therm.	.....	Flooded	....
	R-51-8	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¼ *3¾	L.S.F.	26-27	Therm.	.....	Flooded	....
	P-51-8	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¼ *3¾	L.S.F.	26-27	Therm.	.....	Flooded	....
	R-61-8	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¼ *3¾	L.S.F.	26-27	Therm.	.....	Flooded	....
	P-61-8	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¼ *3¾	L.S.F.	26-27	Therm.	.....	Flooded	....
	R-71-8	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¾ *4¼	L.S.F	26-27	Therm.	.....	Flooded	....
	P-71-8	Con.	Rtry.	...	B	1/6	SO_2	24	16	5¾ *4¼	L.S.F.	26-27	Therm.	.....	Flooded	....
	R-81-8	Con.	Rtry.	...	B	¼	SO_2	24	16	5¾ *4¼	L.S.F.	26-27	Therm.	.....	Flooded	....
	P-81-8	Con.	Rtry.	...	B	¼	SO_2	24	16	5¾ *4¼	L.S.F.	26-27	Therm.	.....	Flooded	....
	LTP-81-8	Con.	Rtry.	...	B	¼	SO_2	.....	.....	6 *4½	L.S.F.	26-27	Therm.	.....	Flooded	....
	LTP-123-8	Con.	Rtry.	...	B	¼	SO_2	.....	.....	10	L.S.F.	32-33	Therm.	.....	Flooded	....
	GR-75-8	Con.	Rtry.	...	B	1/6	SO_2	.....	.....	5 *3½	L.S.F.	26-27	Therm.	.....	Flooded	....
	R-130-8	Con.	Rtry.	...	B	¼	SO_2	.....	.....	10	L.S.F.	32-33	Therm.	.....	Flooded	....
1939	G-3	Her.	Rtry.	...	D	1/12	SO_2	26-27	20-22	.....	H.S.F.	.....	Therm.	.....	Flooded	....
	G-4	Her.	Rtry.	...	D	1/12	SO_2	26-27	20-22	.....	H.S.F.	.....	Therm.	.....	Flooded	....
	G-5	Her.	Rtry.	...	D	1/12	SO_2	26-27	20-22	.....	H.S.F.	.....	Therm.	.....	Flooded	....
	G-6	Her.	Rtry.	...	D	1/12	SO_2	26-27	20-22	.....	H.S.F.	.....	Therm.	.....	Flooded	....
	P-6	Her.	Rtry.	...	D	1/12	SO_2	26-27	20-22	.....	H.S.F.	.....	Therm.	.....	Flooded	....
	P-6A	Her.	Rtry.	...	D	1/12	SO_2	26-27	20-22	.....	H.S.F.	.....	Therm.	.....	Flooded	....
	MH-5	Her.	Rtry.	...	D	1/12	SO_2	26-27	20-22	.....	H.S.F.	.....	Therm.	.....	Flooded	....
	MHP-5	Her.	Rtry.	...	D	1/12	SO_2	26-27	20-22	.....	H.S.F.	.....	Therm.	.....	Flooded	....
	MH-6	Her.	Rtry.	...	D	1/12	SO_2	26-27	20-22	.....	H.S.F.	.....	Therm.	.....	Flooded	....
	MHP-6	Her.	Rtry.	...	D	1/12	SO_2	26-27	20-22	.....	H.S.F.	.....	Therm.	.....	Flooded	....
	MH-8	Her.	Rtry.	...	D	1/8	SO_2	26-27	20-22	.....	H.S.F.	.....	Therm.	.....	Flooded	....
	A-3	Con.	Rtry.	...	B	1/6	SO_2	26	21	1# 13 oz.	H.S.F.	16-18	Therm.	.....	Flooded	....
	M-5	Con.	Rtry.	...	B	1/6	SO_2	26	21	1# 14 oz.	H.S.F.	16-18	Therm.	.....	Flooded	....
	M-5A	Con.	Rtry.	...	B	1/6	SO_2	26	21	1# 14 oz.	H.S.F.	16-18	Therm.	.....	Flooded	....
	M-6	Con.	Rtry.	...	B	1/6	SO_2	26	21	1# 15 oz.	H.S.F.	16-18	Therm.	.....	Flooded	....
	M-6A	Con.	Rtry.	...	B	1/6	SO_2	26	21	1# 15 oz.	H.S.F.	16-18	Therm.	.....	Flooded	....
	M-8	Con.	Rtry.	...	B	1/6	SO_2	26	21	2 lbs.	H.S.F.	16-18	Therm.	.....	Flooded	....
	GO-3	Con.	Rtry.	...	B	1/6	SO_2	26	21	1# 13 oz.	H.S.F.	16-18	Therm.	.....	Flooded	....
	GO-4	Con.	Rtry.	...	B	1/6	SO_2	26	21	1# 14 oz.	H.S.F.	16-18	Therm.	.....	Flooded	....
	GO-5	Con.	Rtry.	...	B	1/6	SO_2	26	21	1# 14 oz.	H.S.F.	16-18	Therm.	.....	Flooded	....
	GO-6	Con.	Rtry.	...	B	1/6	SO_2	26	21	1# 15 oz.	H.S.F.	16-18	Therm.	.....	Flooded	....
	PO-6	Con.	Rtry.	...	B	1/6	SO_2	26	21	1# 14 oz.	H.S.F.	16-18	Therm.	.....	Flooded	....
	PO-6A	Con.	Rtry.	...	B	1/6	SO_2	26	21	1# 14 oz.	H.S.F.	16-18	Therm.	.....	Flooded	....

529. NORGE, Continued

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Average Sleeve Temp. °F. Cut-In	Average Sleeve Temp. °F. Cut-Out	Quantity of SO_2 Refrigerant, lbs.	Refrigerant Control	Quantity of Oil, ozs.	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
	S-5	Con.	Rtry.	...	B	⅛	SO_2	*30	*24	2⅛ SO_2 2ozFreon	H.S.F.	16-18	Therm.	.....	Flooded	....
1939	S-6	Con.	Rtry.	...	B	⅛	SO_2	*30	*24	2¼ SO_2 2ozFreon	H.S.F.	16-18	Therm.	.....	Flooded	....
	S-8	Con.	Rtry.	...	B	⅛	SO_2	*30	*24	2⅜ SO_2 2ozFreon	H.S.F.	16-18	Therm.	.....	Flooded	....
	SN-5	Con.	Rtry.	...	B	⅛	SO_2	*30	*24	2⅛ SO_2 2ozFreon	H.S.F.	16-18	Therm.	.....	Flooded	....
	SN-6	Con.	Rtry.	...	B	⅛	SO_2	*30	*24	2¼ SO_2 2ozFreon	H.S.F.	16-18	Therm.	.....	Flooded	....
	SN-8	Con.	Rtry.	...	B	⅛	SO_2	*30	*24	2⅜ SO_2 2ozFreon	H.S.F.	16-18	Therm.	.....	Flooded	....

*SO_2 charges for late refrigerators equipped with small receivers.

*Fin Temperature—Ice tray shelf temperatures will be 10° to 15° below these readings.

530. O'KEEFE & MERRITT—O'KEEFE & MERRITT CO., 370 E. OLYMPIC BLVD., LOS ANGELES, CALIFORNIA

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temp. °F.	Low Side Press., Vac.	Quantity of SO_2 Refrigerant, lbs.	Refrigerant Control	Quantity of Oil, ozs.	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
1936	636	Con.	Recip.	2	B	⅛	SO_2	14	5/″	3	Ex. Va.	18	Therm.	.....	Shell	....
	736	Con.	Recip.	2	B	⅛	SO_2	14	5/″	3½	Ex. Va.	18	Therm.	.....	Shell	....
	1036	Con.	Recip.	2	B	⅛	SO_2	14	5/″	3¾	Ex. Va.	18	Therm.	.....	Shell	....
1937	437	Con.	Rtry.	...	D	⅛	SO_2	14	5/″	2.5	L.S.F.	24	Therm.	.....	Porc.	4
	537	Con.	Rtry.	...	D	⅛	SO_2	14	5/″	2.5	L.S.F.	24	Therm.	.....	Porc.	4

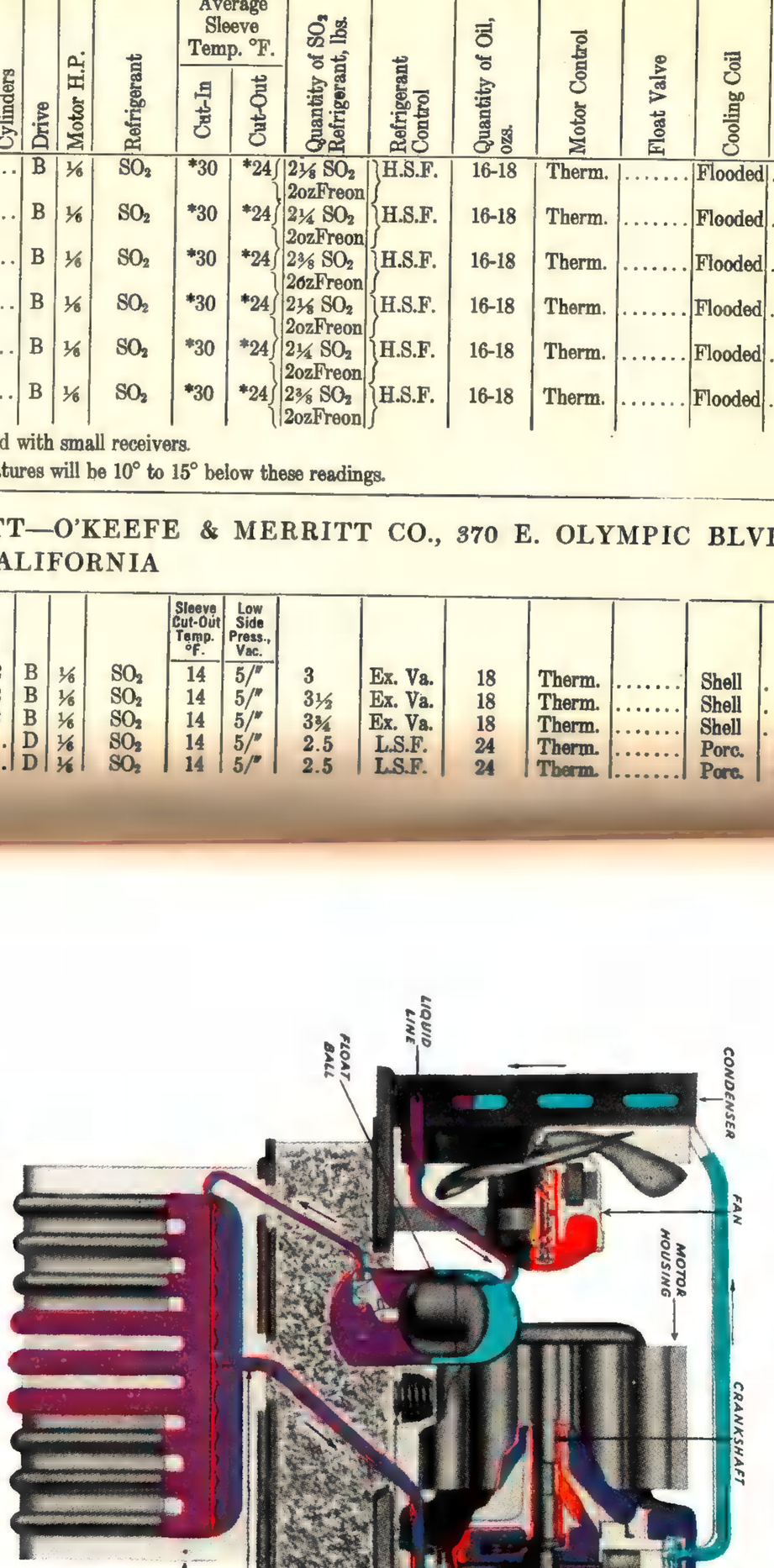


Fig. 366. The Westinghouse domestic refrigerator cycle (*Courtesy of: Westinghouse Electric & Mfg. Company*)

530. O'KEEFE & MERRITT, Continued

	376	Con.	Rtry.	...	D	1/6	SO_2	14	5/″	3.0	L.S.F.	24	Therm.	.....	Porc.	4
	377	Con.	Rtry.	...	D	1/6	SO_2	14	5/″	3.5	L.S.F.	24	Therm.	.....	Porc.	4
1938	4438	Con.	Rtry.	1	B	1/6	SO_2	14	5/″	3	L.S.F.	18	Therm.	.....	Porc.	4
	538	Con.	Rtry.	1	B	1/6	SO_2	14	5/″	3	L.S.F.	18	Therm.	.....	Porc.	4
	638	Con.	Rtry.	2	B	1/5	SO_2	14	5/″	4	L.S.F.	24	Therm.	.....	Porc.	4
	738	Con.	Rtry.	2	B	1/5	SO_2	14	5/″	5	L.S.F.	24	Therm.	.....	Porc.	4
1939	4538	Con.	Rtry	1	D	1/6	SO_2	14	5/″	3	Ex. Va.	16	Therm.	.....	Shell	4
	4539	Her.	Recip.	1	D	1/8	F-12	14	14	14 oz.	Cap. T.	24	Therm.	.....	Shell	4
	6639	Her.	Recip.	1	D	1/6	F-12	14	14	16 oz.	Cap. T.	24	Therm.	.....	Shell	4
	9639	Her.	Recip.	1	D	1/6	F-12	14	14	16 oz.	Cap. T.	24	Therm.	.....	Shell	4
	639	Her.	Recip.	1	D	1/6	F-12	14	14	16 oz.	Cap. T.	24	Therm.	.....	Shell	4
	739	Her.	Recip.	1	D	1/6	F-12	14	14	18 oz.	Cap. T.	24	Therm.	.....	Shell	4

531. PHILCO CONSERVADOR—PHILCO REFRIGERATOR CO., INDIANAPOLIS, INDIANA

1939	K5	Her.	Recip.	1	D	1/8	F-12	10	12	1.36	Cap. T.	50	Therm.	.....	Shell	....
	K6	Her.	Recip.	1	D	1/8	F-12	10	12	1.36	Cap. T.	50	Therm.	.....	Shell	....
	K7	Her.	Recip.	1	D	1/8	F-12	10	12	1.40	Cap. T.	50	Therm.	.....	Shell	....
	KX4	Her.	Recip.	1	D	1/8	F-12	10	12	1.25	Cap. T.	50	Therm.	.....	Shell	....
	KX6	Her.	Recip.	1	D	1/8	F-12	10	12	1.25	Cap. T.	.....	Therm.	.....	Shell	....
	KC5	Her.	Recip.	1	D	1/8	F-12	10	12	1.36	Cap. T.	50	Therm.	.....	Shell	....
	KC6	Her.	Recip.	1	D	1/8	F-12	10	12	1.36	Cap. T.	50	Therm.	.....	Shell	....
	KC7	Her.	Recip.	1	D	1/8	F-12	10	12	1.40	Cap. T.	50	Therm.	.....	Shell	....

532. POTTER — POTTER REFRIGERATOR CORPORATION, 220 DELAWARE AVENUE, BUFFALO, NEW YORK

1936	*C-46	Con.	Recip.	1	B	1/6	Ch. 3 Cl.	.....	5½	1¼	Ex. Va.	⅜ pts.	Therm.	.....	Tube	....
	*C-66	Con.	Recip.	1	B	1/6	Ch. 3 Cl.	.....	5½	1¼	Ex. Va.	⅜	Therm.	.....	Tube	....
	‡L-66	Con.	Recip.	2	B	1/5	Ch. 3 Cl.	.....	3½	1¼	Ex. Va.	1¼	Therm.	.....	Tube	....
	‡L-86	Con.	Recip.	2	B	1/5	Ch. 3 Cl.	.....	3½	1¼	Ex. Va.	1½	Therm.	.....	Tube	....
	xD-106	Con.	Recip.	2	B	1/6	Ch. 3 Cl.	.....	1½	1¼	Ex. Va.	1½	Therm.	.....	Tube	....
	xD-136	Con.	Recip.	2	B	1/5	Ch. 3 Cl.	.....	1½	1¼	Ex. Va.	1½	Therm.	.....	Tube	....
1937	*C-47	Con.	Recip.	1	B	1/6	F-12	.....	10½	1½	Ex. Va.	⅜	Therm.	.....	Tube	....
Early	*C-67	Con.	Recip.	1	B	1/6	F-12	.....	10½	1½	Ex. Va.	⅜	Therm.	.....	Tube	....

532. POTTER, Continued

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure, Vac.	Quantity of Refrigerant, lbs.	Refrigerant Control	Quantity of Oil, p.s.	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
	‡L-67	Con.	Recip.	1	B	1/6	F-12	.....	10½	1½	Ex. Va.	⅔	Therm.	.....	Tube	....
	‡L-87	Con.	Recip.	2	B	1/6	F-12	.....	8½	1½	Ex. Va.	1	Therm.	.....	Tube	....
	xD-107	Con.	Recip.	2	B	1/6	F-12	.....	5½	1½	Ex. Va.	1	Therm.	.....	Tube	....
	xD-137	Con.	Recip.	2	B	1/6	F-12	.....	5½	1½	Ex. Va.	1	Therm.	.....	Tube	....
	xD-157	Con.	Recip.	2	B	1/6	F-12	.....	5½	1½	Ex. Va.	1	Therm.	.....	Tube	....
1937	‡C-68	Con.	Recip.	1	B	1/6	F-12	.....	10½	1½	Ex. Va.	⅔	Therm.	.....	Tube	....
Late	‡C-78	Con.	Recip.	1	B	1/6	F-12	.....	10½	1½	Ex. Va.	⅔	Therm.	.....	Tube	....
	‡C-88	Con.	Recip.	2	B	1/6	F-12	.....	10½	1½	Ex. Va.	1	Therm.	.....	Tube	....
	xCF-808	Con.	Recip.	2	B	1/6	F-12	.....	4	1½	Ex. Va.	1	Therm.	.....	Tube	....
	xD-108	Con.	Recip.	2	B	1/6	F-12	.....	5½	1½	Ex. Va.	1	Therm.	.....	Tube	....
	xD-138	Con.	Recip.	2	B	1/6	F-12	.....	5½	1½	Ex. Va.	1	Therm.	.....	Tube	....
	xD-157	Con.	Recip.	2	B	1/6	F-12	.....	5½	1½	Ex. Va.	1	Therm.	.....	Tube	....
1938-																
1939	‡S1-860	Con.	Recip.	1	B	1/6	F-12	.....	8	1½	Ex. Va.	10	Therm.	.....	Tube	....
	‡Ls-870	Con.	Recip.	2	B	1/6	F-12	.....	8	1½	Ex. Va.	16	Therm.	.....	Tube	....
	xSD-810	Con.	Recip.	2	B	1/6	F-12	.....	5	1½	Ex. Va.	16	Therm.	.....	Tube	....
	xSD-813	Con.	Recip.	2	B	1/6	F-12	.....	5	1½	Ex. Va.	16	Therm.	.....	Tube	....
	xSD-815	Con.	Recip.	2	B	1/6	F-12	.....	5	1½	Ex. Va.	16	Therm.	.....	Tube	....

*Dry Cold Models. ‡Air Conditioned
x Air Conditioned general storage compartment with large separate frozen storage compartment.

533. SPARTON—THE SPARKS-WITHINGTON CO., JACKSON, MICHIGAN

1936	D939	Con.	Recip.	1	B	1/6	SO_2	.....	6.5	20	Ex. Va.	14 oz.	Therm.	.....	Tube	....
1937	257	Con.	Recip.	1	B	1/8	SO_2	14	6.5	20	Ex. Va.	14	Therm.	.....	Tube	....
	317	Con.	Recip.	1	B	1/8	SO_2	14	6.5	20	Ex. Va.	14	Therm.	.....	Tube	....
	467	Con.	Recip.	1	B	1/6	SO_2	14	6.5	20	Ex. Va.	14	Therm.	.....	Tube	....
	617	Con	Recip.	1	B	1/6	SO_2	10	.....	20	Th E. V.	14	Therm.	.....	Tube	....

533. SPARTON, Continued

	747	Con.	Recip	1	B	1/6	SO_2	10	.....	20	Th. E. V.	14	Therm.	.....	Tube	....
	947	Con.	Recip.	2	B	1/6	SO_2	10	.....	20	Th. E. V.	16	Therm.	.....	Tube	....
1938	318	Con.	Recip.	1	B	1/8	SO_2	10	.....	20	Th. E. V.	11	Therm.	.....	Tube	....
	458	Con.	Recip.	1	B	1/8	SO_2	10	.....	20	Th. E. V.	11	Therm.	.....	Tube	....
	468	Con.	Recip.	1	B	1/8	SO_2	10	.....	20	Th. E. V.	14	Therm.	.....	Tube	....
	38	Con.	Recip.	1	B	1/6	SO_2	10	.....	20	Th. E. V.	14	Therm.	.....	Tube	....
	618	Con.	Recip.	1	B	1/6	SO_2	10	.....	20	Th. E. V.	14	Therm.	.....	Tube	....
	748	Con.	Recip.	1	B	1/6	SO_2	10	.....	20	Th. E. V.	16	Therm.	.....	Tube	....
	948	Con.	Recip.	2	B	1/6	SO_2	10	.....	20	Th. E. V.	11	Therm.	.....	Tube	....
1939	319	Con.	Recip	1	B	1/8	SO_2	10	.....	20	Th. E. V.	11	Therm.	.....	Tube	....
	459	Con.	Recip.	1	B	1/8	SO_2	10	.....	20	Th. E. V.	11	Therm.	.....	Tube	....
	469	Con.	Recip.	1	B	1/8	SO_2	10	.....	20	Th. E. V.	14	Therm.	.....	Tube	....
	39	Con.	Recip.	1	B	1/6	SO_2	10	.....	20	Th. E. V.	14	Therm.	.....	Tube	....
	619	Con.	Recip.	1	B	1/6	SO_2	10	.....	20	Th. E. V.	14	Therm.	.....	Tube	....
	749	Con.	Recip.	1	B	1/6	SO_2	10	.....	20	Th. E. V.	14	Therm.	.....	Tube	....
	949	Con.	Recip.	2	B	1/6	SO_2	10	.....	20	Th. E. V.	16	Therm.	.....	Tube	....

534. STEWART-WARNER — STEWART-WARNER CORPORATION, CHICAGO, ILLINOIS

1936	456	Con.	Recip.	1	B	1/6	SO_2	.....	7-10	5*	L.S.F.	20 oz.	Therm.	.....	Flooded	....
	556	Con.	Recip.	2	B	1/6	SO_2	.....	3-6	5*	L.S.F.	24-	Therm.	.....	Flooded	....
	566	Con.	Recip.	2	B	1/6	SO_2	.....	4-7	5*	L.S.F.	24-	Therm.	.....	Flooded	....
	666	Con.	Recip.	2	B	1/6	SO_2	.....	4-7	5*	L.S.F.	24-	Therm.	.....	Flooded	....
	766	Con.	Recip.	2	B	1/6	SO_2	.....	3-6	5*	L.S.F.	24-	Therm.	.....	Flooded	....
	866	Con.	Recip.	2	B	1/6	SO_2	.....	3-6	5*	L.S.F.	24-	Therm.	.....	Flooded	....
	656	Con.	Recip.	2	B	1/6	SO_2	.....	3-6	5*	L.S.F.	24-	Therm.	.....	Flooded	....
1937	457	Con.	Recip.	1	B	1/6	SO_2	.....	7-10	5*	L.S.F.	20-	Therm.	.....	Flooded	....
	357	Con.	Recip.	1	B	1/6	SO_2	.....	.....	5*	L.S.F.	20-	Therm.	.....	Flooded	....
	700	Con.	Recip.	2	B	1/6	SO_2	.....	.....	5*	L.S.F.	24-	Therm.	.....	Flooded	....
	557	Con.	Recip.	2	B	1/6	SO_2	.....	3-6	5*	L.S.F.	24-	Therm.	.....	Flooded	....
	567	Con.	Recip.	2	B	1/6	SO_2	.....	3-6	5*	L.S.F.	24-	Therm.	.....	Flooded	....
	657	Con.	Recip.	2	B	1/6	SO_2	.....	4-7	5*	L.S.F.	24-	Therm.	.....	Flooded	....
	667	Con.	Recip.	2	B	1/6	SO_2	.....	4-7	5*	L.S.F.	24-	Therm.	.....	Flooded	....
	767	Con.	Recip.	2	B	1/6	SO_2	.....	3-6	5*	L.S.F.	24-	Therm.	.....	Flooded	....
	867	Con.	Recip.	2	B	1/6	SO_2	.....	3-6	5*	L.S.F.	24-	Therm.	.....	Flooded	....
1938	550	Con.	Recip.	2	B	1/6	SO_2	.....	.....	5*	L.S.F.	24-	Therm.	.....	Flooded	....

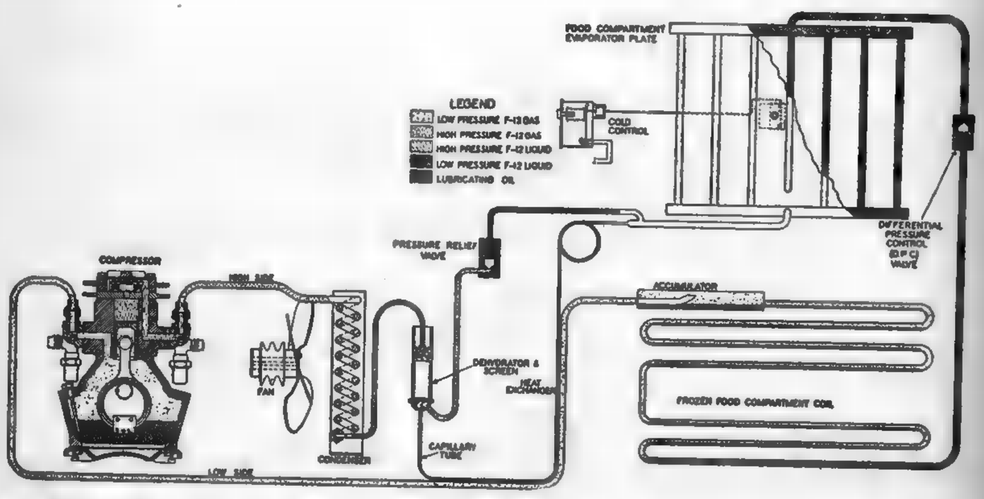


Fig. 374. The Stewart-Warner Dual Temperature unit cycle diagram. Note the pressure relief valve and the differential pressure control.
(Courtesy of: Stewart-Warner Corporation)

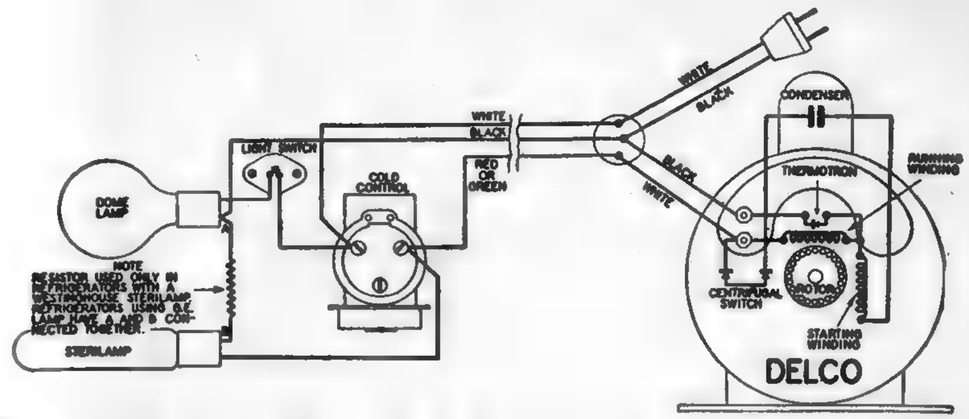


Fig. 375. The Stewart-Warner Dual Temperature wiring diagram. Note the use of a Thermotron for motor protection and the use of a Sterilamp for better food preservation.
(Courtesy of: Stewart-Warner Corporation)

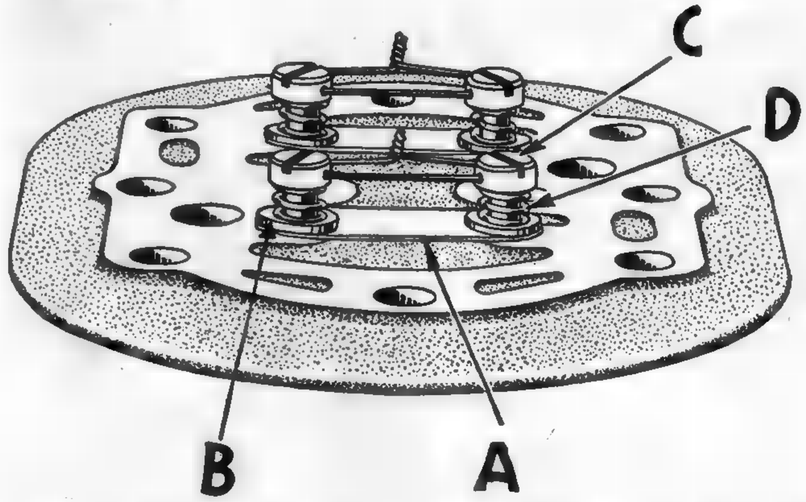


Fig. 376. Stewart-Warner Compressor Discharge Valve Plate.
A. Discharge Valve; B. Reinforcing Washer; C. Pilot Stud; D. Valve Spring.
(Courtesy of: Stewart-Warner Corporation)

534. STEWART-WARNER, Continued

Year	Model	Design	Compressor	Cylinders	Drive	Motor H.P.	Refrigerant	Sleeve Cut-Out Temperature °F.	Low Side Pressure, Vac.	Quantity of Refrigerant, lbs.	Refrigerant Control	Quantity of Oil, ozs.	Motor Control	Float Valve	Cooling Coil	Cooling Coil Oil
1938	770	Con.	Recip.	2	B	1/6	SO_2	.....	.....	5*	L.S.F.	24–	Therm.	.....	.....	....
	458	Con.	Recip.	1	B	1/6	SO_2	.....	.....	5*	L.S.F.	20–	Therm.	.....	.....	....
	558	Con.	Recip.	2	B	1/6	SO_2	.....	.....	5*	L.S.F.	24–	Therm.	.....	.....	....
	568	Con.	Recip.	2	B	1/6	SO_2	.....	.....	5*	L.S.F.	24–	Therm.	.....	.....	....
	658	Con.	Recip.	2	B	1/6	SO_2	.....	.....	5*	L.S.F.	24–	Therm.	.....	.....	....
	668	Con.	Recip.	2	B	1/6	SO_2	.....	.....	5*	L.S.F.	24–	Therm.	.....	.....	....
	768	Con.	Recip.	2	B	1/6	SO_2	.....	.....	5*	L.S.F.	24–	Therm.	.....	.....	....
1939	#769	Con.	Recip.	2	B	1/4	F-12	29	.....	2¾	Cap. T.	20	Therm.	.....	.....	....

*Of this total, the 2 tray uses 2.5 pounds, the 4 tray 3 pounds and the 5 tray 3½ pounds.
–Four (4) ounces in evaporator.
#Dual temperature unit, 2 cooling coils using differential pressure valves. Also uses a Stenlamp, an ultra violet ray lamp for killing bacteria and mold (uses 5 watts).

535. TRUPAR—TRUPAR MFG. CO., SIDNEY, OHIO

1936	C-16	Con.	Recip.	2	B	1/6	M. C.	.....	.....	1	Ex. Va.	14	Therm.	.....	Shell	....
	C-20	Con.	Recip.	2	B	1/5	M. C.	.....	.....	1	Ex. Va.	14	Therm.	.....	Shell	....

536. UNIVERSAL COOLER—UNIVERSAL COOLER CORPORATION, MELVILLE & GREEN, DETROIT, MICHIGAN

1936	B	Con.	Recip.	1	B	1/6	M. C.	.....	5½	1½	Ex. Va.	11	Therm.	.....	Tube	....
	D	Con.	Recip.	2	B	1/5	M. C.	.....	5½	1½	Ex. Va.	16	Therm.	.....	Tube	....
1937	B	Con.	Recip.	1	B	1/6	F-12	14	.....	1½	Th. E. V.	11	Therm.	.....	Tube	....
	DD	Con.	Recip.	2	B	1/5	F-12	14	.....	1½	Th. E. V.	16	Therm.	.....	Tube	....
1938	A	Con.	Recip.	1	B	1/6	F-12	.....	.....	1¼	Th. E. V.	8	Therm.	.....	Tube	....
	DD	Con	Recip.	2	B	1/5	F-12	.....	.....	1½	Th. E. V.	12	Therm.	.....	Tube	....

536. UNIVERSAL COOLER, Continued

1939	A	Con.	Recip.	1	B	1/6	F-12	.....	.....	¾	Cap. T.	▮	Therm.	.....	Alum.T.	....
	A	Con.	Recip.	1	B	1/6	F-12	.....	.....	1¼	Th. E. V.	8	Therm.	.....	Alum.T.	....
	DD	Con.	Recip.	2	B	1/5	F-12	.....	.....	1½	Th. E. V.	12	Therm.	.....	Alum.T.	....

537. UNIVERSAL REFRIGERATOR — LANDERS, FRARY & CLARK, NEW BRITAIN, CONNECTICUT

1936	150ER	Con.	Rtry.	...	B	1/6	SO_2	.....	.....	4-5	L.S.F.	32	Therm.	.....	Shell	....
	.....	Con.	Rtry.	...	B	¼	SO_2	.....	.....	4-5	L.S.F.	32	Therm.	.....	Shell	....
1937	.....	Con.	Rtry.	...	B	1/6	SO_2	.....	.....	4-5	L.S.F.	32	Therm.	.....	Shell	....
	.....	Con.	Rtry.	...	B	1/5	SO_2	.....	.....	4-5	L.S.F.	32	Therm.	.....	Shell	....
1938	.....	Con.	Rtry.	...	B	1/6	SO_2	.....	.....	4-5	L.S.F.	32	Therm.	.....	Shell	....
	.....	Con.	Rtry.	...	B	1/5	SO_2	.....	.....	4-5	L.S.F.	32	Therm.	.....	Shell	....
1939	.....	Con.	Rtry.	...	B	1/6	SO_2	.....	.....	4 to 5	L.S.F.	32	Therm.	.....	Shell	....
	.....	Con.	Rtry.	...	B	1/5	SO_2	.....	.....	4 to 5	L.S.F.	32	Therm.	.....	Shell	....

538. NEW COMMERCIAL MOTOR CONTROLS:

The problem of keeping good refrigeration temperatures with good humidity characteristics, and without excessive frosting of the cooling coils, has always been an engineering problem in commercial refrigeration. Recently several methods have been devised to alleviate the situation.

Ranco Inc. have designed a control which operates on the principle of using the cabinet temperature to produce the cut-out and the coil temperature to produce the cut-in. This insures correct cabinet temperatures before the unit stops and a defrosted coil before the machine starts on every cycle while maintaining good humidity characteristics. The control may be used either in single or multiple installations.

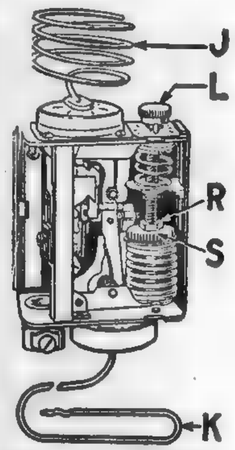


Fig. 377. Defrosting Thermostat. J. Air bulb; L. Fixture temperature adjustment; R. Lock nut; S. Defrost adjustment; K. Coil bulb
(Courtesy of: Ranco, Incorporated)

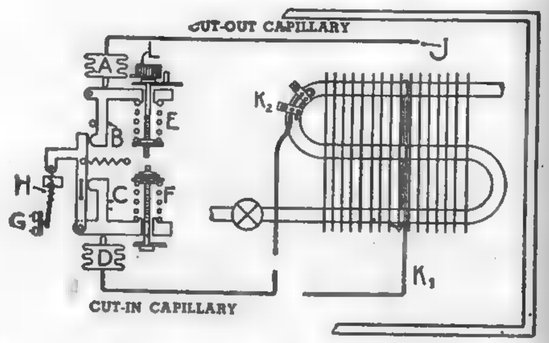


Fig. 378. Schematic Diagram of the Ranco Defrost control. A. Cut-out bellows; B. Cut-out lever; C. Cut-in lever; D. Cut-in bellows; E. Cut-out adjusting spring; F. Cut-in adjusting spring; G. Contact points; H. Snap action toggle and spring; I. Coordinating lever; J. Cut-out capillary; K1 and K2. Cut-in bulb locations (K2 preferred); L. Cut-out adjusting knob
(Courtesy of: Ranco, Incorporated)

Figures 377 and 378 illustrate the construction of this control.

Minneapolis-Honeywell Inc. are manufacturing a control called the "Polartron," which uses a thermostat in conjunction with a "Series 10 connected Polartron" to obtain cor-

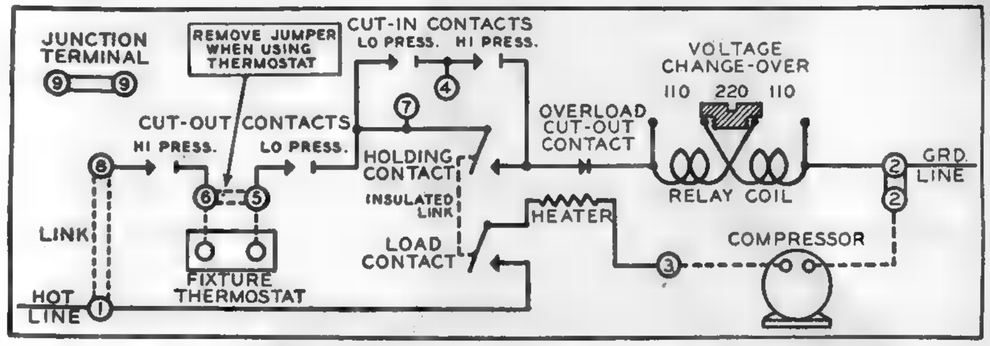


Fig. 379. A schematic diagram of the wiring of the "Polartron"
(Courtesy of: The Minneapolis-Honeywell Regulator Company)

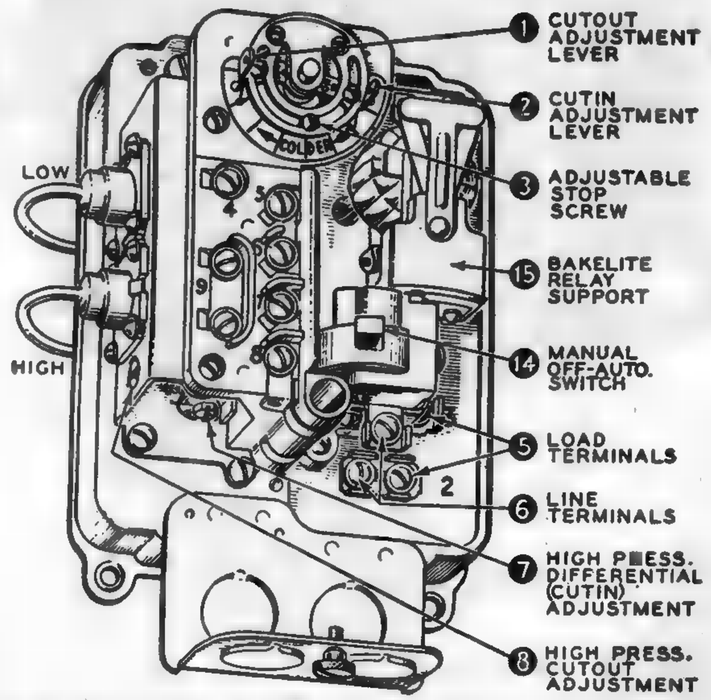


Fig. 380. A view of the internal construction of the "Polartron"
(Courtesy of: The Minneapolis-Honeywell Regulator Company)

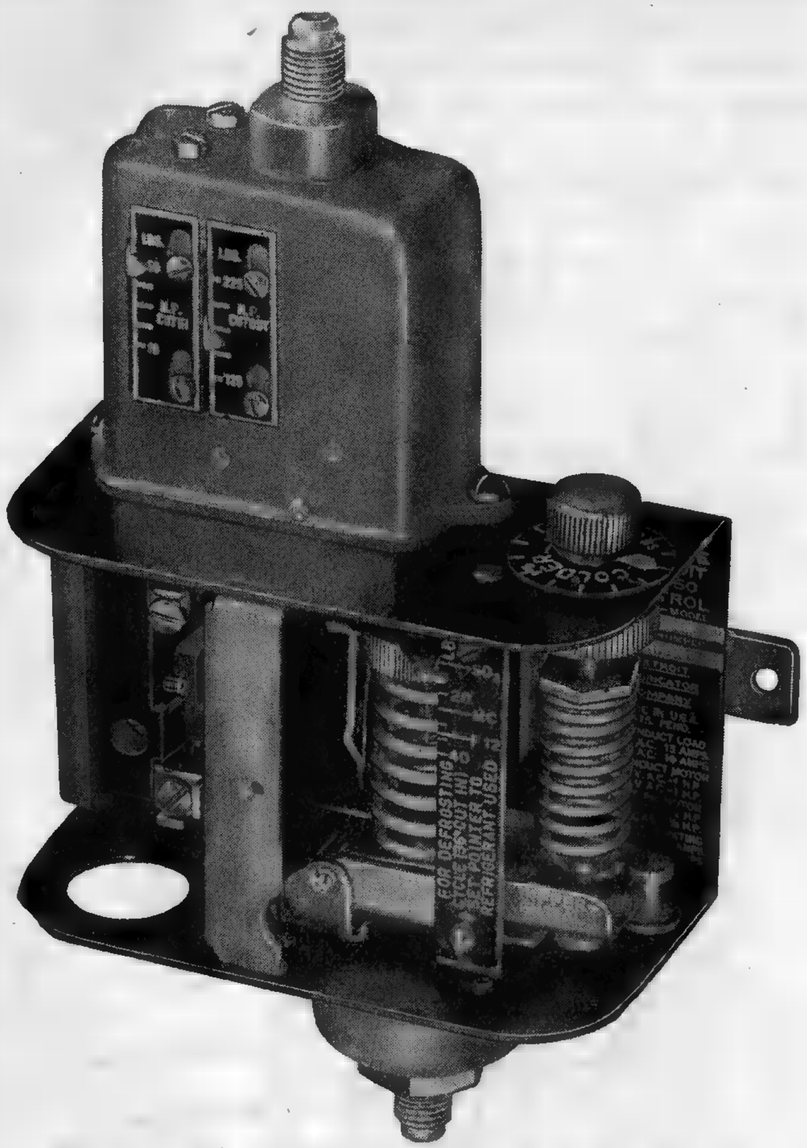


Fig. 381. The Detroit Lubricator "Meat Box Control"
(Courtesy of: The Detroit Lubricator Company)

rect cabinet temperature on the cut-out while ■ pressure element, also connected to the Polartron, controls the cut-in point and thereby determines that the frost on the coils will

melt away on each cycle. This control also incorporates ■ high-pressure safety cut-out which will not allow the machine to start unless the head pressures are down to normal. An overload relay for safety in case of excessive motor loads may also be obtained with this motor control. Figure 379 explains the diagrammatic hook-up of the control; Figure 380 shows the interior of the Polartron.

The Detroit Lubricator Company has developed a commercial control which solves the problem of maintaining good refrigeration temperatures during low ambient temperature periods (ambient temperature refers to outside, i.e., surrounding temperature). This action is accomplished by cycling the unit with the high-pressure control. If the condensing pressure falls to a certain level, due to the cooling action of the ambient temperature, the condensing unit will *cut-in*, thereby cycling the unit, even though the low-pressure cut-in may not have been reached in the cabinet. This more frequent cycling eliminates the spoilage film that sometimes forms on meats if an ordinary control is used under these conditions. Figure 381 illustrates the construction of this control.

Fig. 382. A. The exterior view of the Nofrost commercial motor control.
(Courtesy of: The Penn Electric Switch Company)

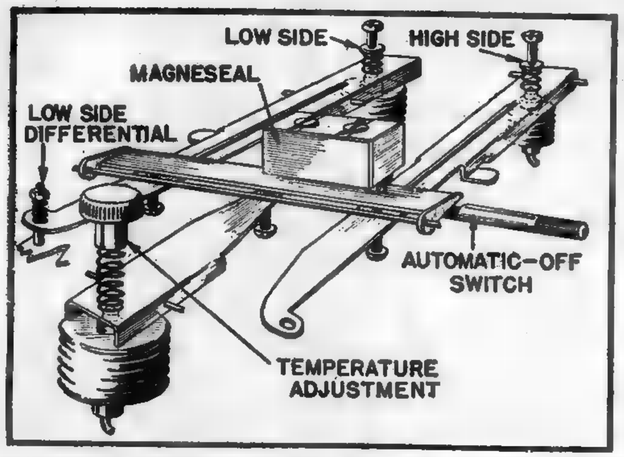


Fig. 382B. A schematic diagram of the internal construction of the Nofrost control.
(Courtesy of: The Penn Electric Switch Company)

The Penn Electric Switch Company has introduced a "Nofrost" commercial control to the refrigeration field which incorporates a thermostatic cut-out, a low pressure side cut-in and a high pressure safety cut-out. This control makes possible a thorough defrosting of the coil on each cycle while maintaining correct cabinet temperatures and humidity. Figure 382 shows the construction of this control.

Another innovation recently introduced to users of commercial refrigeration is the use of ultra-violet-ray lamps to kill bacteria and mold in the cabinet. These lamps, which radiate very little heat but which emanate a high percentage of ultra-violet rays, have proved very successful in reducing meat spoilage. These lamps are now available for installation in any refrigerator cabinet.

539. NEW EXPANSION VALVE DESIGNS:

In the past few years refinements in design have produced several innovations in the construction of expansion valves.

A renewed use of improved diaphragms in place of bellows has been one outstanding development, while placing the

valve adjustment in the body of the valve rather than on the capillary tube side of the valve is also becoming common.

The Detroit Lubricator Company has introduced a diaphragm automatic expansion valve which is very compact and efficient. It has a ¼-inch female pipe outlet (cooling coil connection) and a ¼-inch SAE flare inlet. One will note from Figure 383 that the needle is of the "floating" design to insure accurate alignment at all times. The needle and seat are made of a special metal, "Delubaloy."

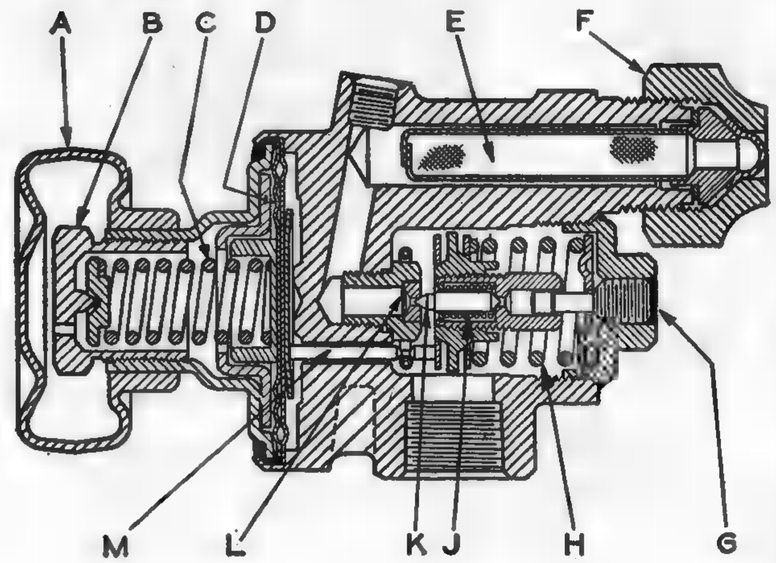


Fig. 383. The Detroit Lubricator diaphragm automatic expansion valve. A. Rubber cap; B. Adjusting screw; C. Adjusting spring; D. Diaphragm; E. Screen; F. Inlet nut; G. Factory adjustment; H. Spring; J. Spring; K. Needle; L. Seat; M. Pin.
(Courtesy of: Detroit Lubricator Company)

One of the Detroit Lubricator Company's thermostatic expansion valves is shown in Figure 384. Note the non-destructible spacer (B or C) made of stainless steel and the coiled capillary tube (F) in place of the usual bulb. This latter provides quicker thermal action due to the more surface contact for the refrigerant sealed in the thermal element.

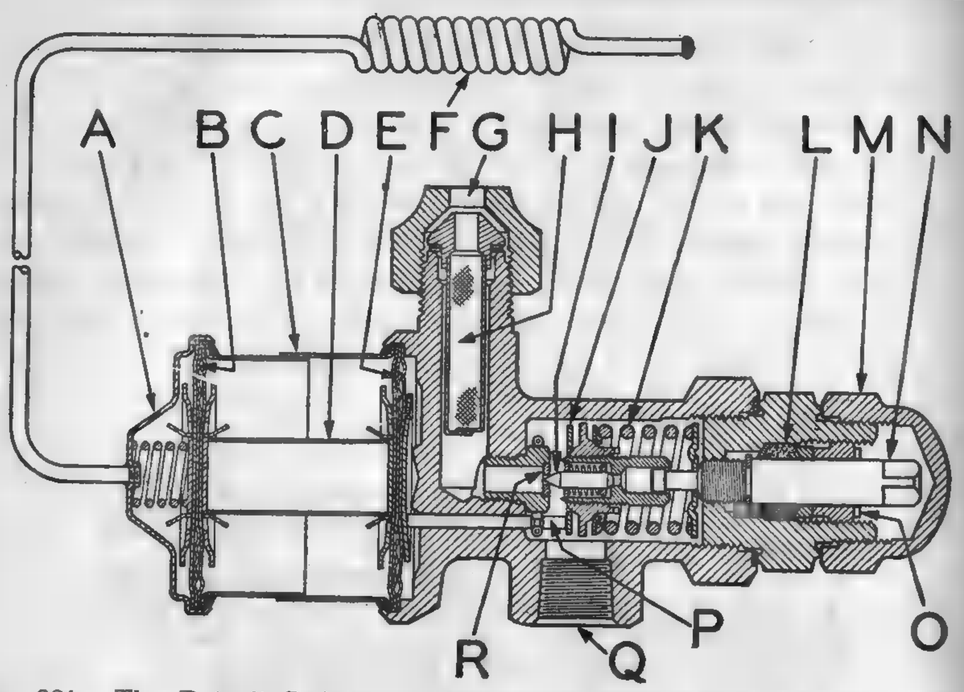


Fig. 384. The Detroit Lubricator diaphragm thermostatic expansion valve. A. Cap; B. Diaphragm; C. Spacer; D. Spacer pin; E. Diaphragm; F. Power element; G. Inlet; H. Screen; I. Needle; J. Needle shoulder; K. Spring; L. Packing; M. Cap; N. Adjusting stem; O. Packing nut; P. Pin; Q. Outlet; R. Seat
(Courtesy of: Detroit Lubricator Company)

This valve is "gas charged," meaning that the thermal element charge is limited, preventing excessive thermal element pressures and preventing accidental opening of the valve needle during shut-down periods. These valves may be obtained with any maximum thermal element pressure one desires.

The Automatic Products Company has placed two expansion valves on the market. The automatic expansion valve, Figure 385, is of ¼ to ½ ton capacity and has an adjustable range from 20 inches of mercury vacuum to 30#/inch² pressure. Its orifice is .035 inch and the valve is only 3½ inches long. The seat is stainless steel while the needle is made of Stellite.

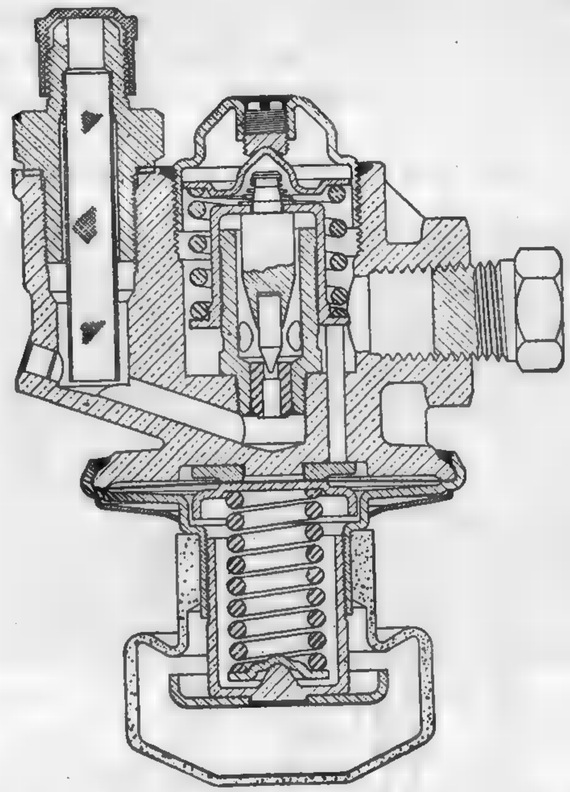


Fig. 385. The Automatic Products expansion valve
(Courtesy of: Automatic Products Company)

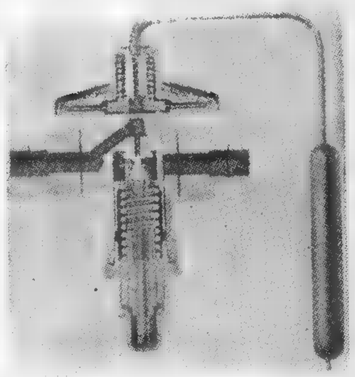


Fig. 386. The Automatic Products thermostatic expansion valve
(Courtesy of: Automatic Products Company)

The thermostatic expansion valve shown in Figure 386 has a forged brass body and a beryllium copper diaphragm. Note the sweat (soldered) flanges. The capillary tube is protected from "kinking" at the expansion valve body connection by a spring coiled around it and soldered to the body. The valve body may be mounted in any position without interfering with the operation of the valve.

One of the most popular thermostatic expansion valves is the one manufactured by the Alco Valve Company. Note the different type of adjustment and the reversed refrigerant flow past the needle and seat (Figure 387). The equalizing

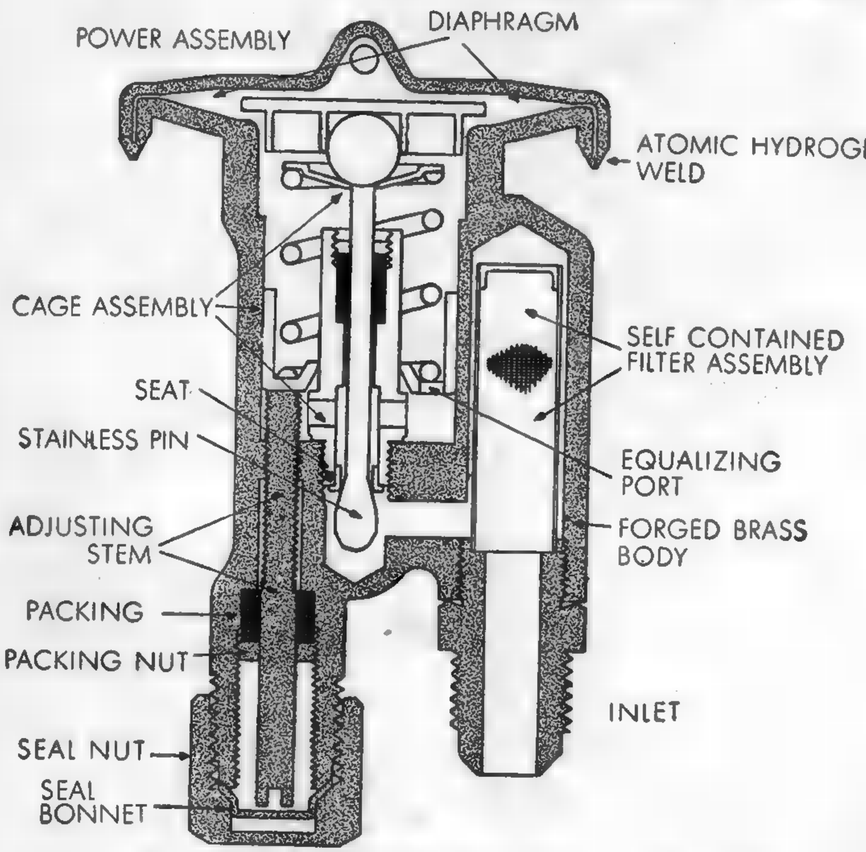


Fig. 387. The Alco thermostatic expansion valve
(Courtesy of: Alco Valve Company)

port enables the pressure on the inner face of the diaphragm to always remain equal to the low side pressure.

The Fedders Manufacturing Company has produced expansion valves for many years and one of their most popular models is shown in Figure 388. This valve utilizes the double

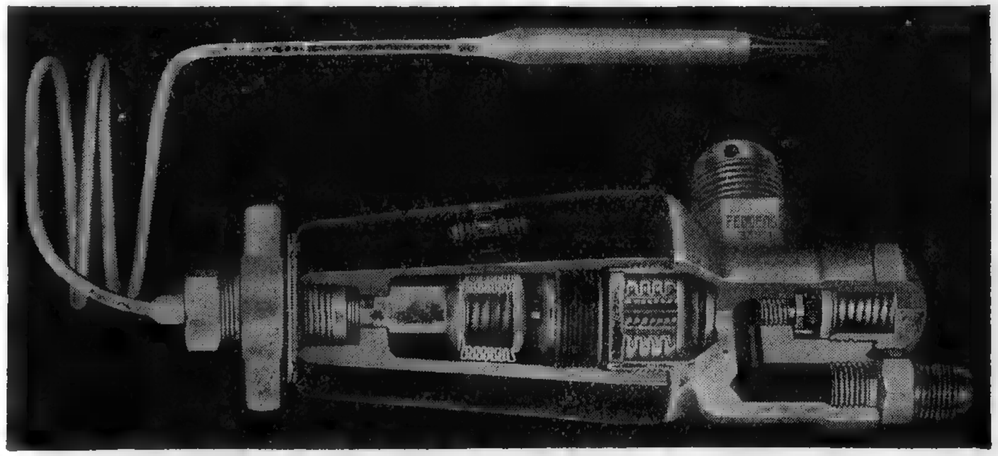


Fig. 388. The Fedders thermostatic expansion valve
(Courtesy of: The Fedders Mfg. Company)

bellows design. The color of the tip of the thermal element bulb indicates the refrigerant of the system with which the valve is to be used, i.e., blue for sulphur dioxide, red for methyl chloride, and yellow for Freon 12. The thermal bellows may be removed from the housing without danger of injuring the thermal element.

A good thermal contact between the bulb and the suction line is of utmost importance to enable satisfactory operation of the thermostatic expansion valve. The suction line should be cleaned (sanded) before fastening the bulb to it and it should then be covered with some insulation for at least 10 inches along the suction line on both sides. The insulating prevents any air currents from warming or cooling the bulb to the detriment of its control over the refrigerant in the coil.

540. SERVICE KIT FOR HERMETIC UNITS:

The rapid growth of hermetic and semi-hermetic units has resulted in the development of special tools and equipment to service and repair them. A special valve adaptor set is now manufactured by several companies to enable a serviceman to check the pressures and to charge and discharge these units. A valve using a sliding valve stem and several adaptor fittings and drives enables this tool to be used on practically all of the units (Figure 389).

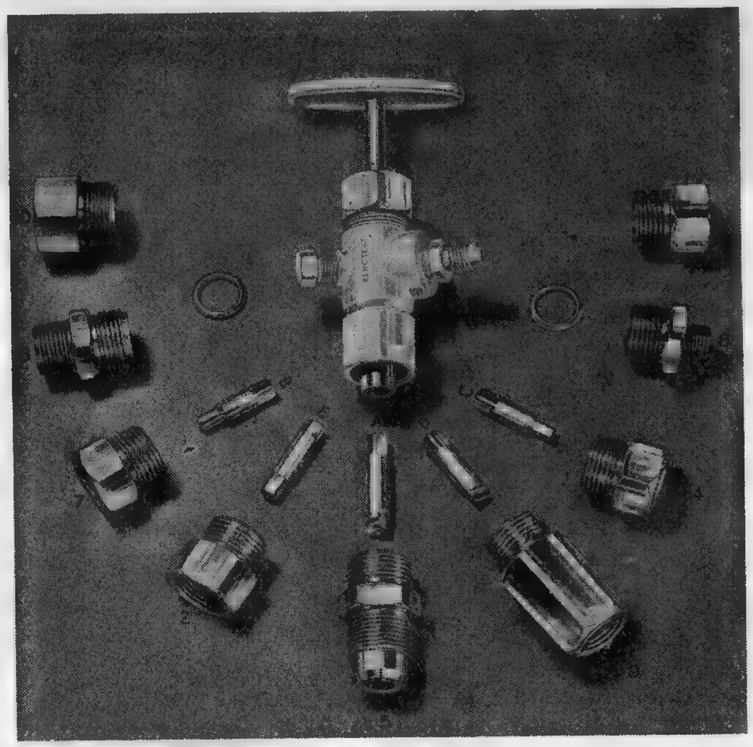


Fig. 389. The Kerotest valve kit for hermetic units. Number 1 through 10 are adaptor fittings for different units while A through E are valve drive adaptors
(Courtesy of: Kerotest Manufacturing Company)

541. GAUGE MANIFOLDS FOR TESTING AND SERVICING:

A service device which has been of considerable aid to servicemen for several years is a service gauge and testing manifold. Figure 390. Its use enables one to charge and discharge

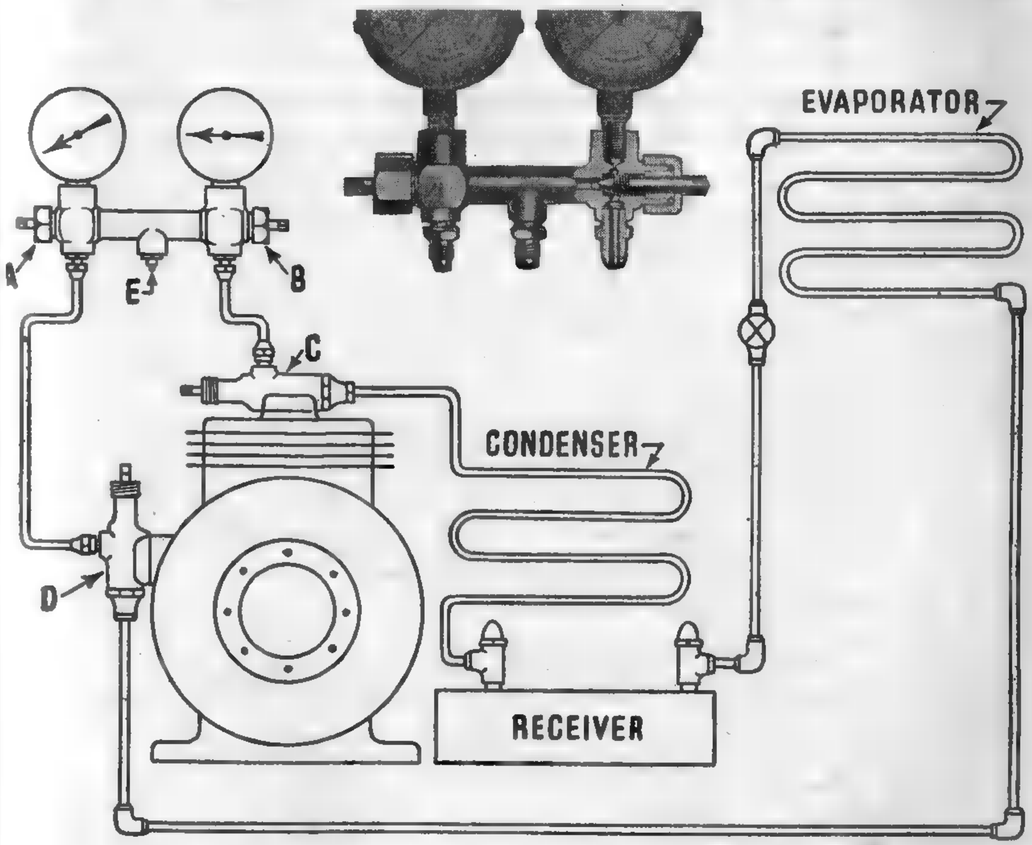


Fig. 390. A service gauge manifold
A. A compound gauge manifold valve
B. A high pressure gauge manifold valve
C. Compressor discharge service valve
D. Compressor suction service valve
E. Purging and charging manifold connections
(Courtesy of: Mueller Brass Company)

a system, check the pressures, add oil to a system, add liquid dryers to a system, by-pass the compressor, unload the gauge

lines of high pressure liquid and gas and perform many other operations without replacing gauges and operating inaccessible service connections.

A typical manifold provides two gauge openings, three line connections and two shut-off valves that separate the gauge openings from the center line connection. This manifold enables the serviceman to connect his gauges to the system and then allows him to do practically all service and adjustment operations without removing the gauges even temporarily.

After the testing manifold has been installed as indicated in Figure 390, the various service and testing operations may be performed as follows:

1. Observe operating pressures by:
   Closing valve A
   Closing valve B
   Cracking open back seat of valve C
   Cracking open back seat of valve D
2. Charge refrigerant through compressor by:
   Connecting refrigerant drum to E
   Opening valve A
   Closing valve B
   Cracking open back seat of valve C
   Closing front seat of valve D
3. Purge receiver by:
   Closing valve A
   Opening valve B
   Back seating then crack open valve C
4. Charge liquid into high side by:
   Connecting refrigerant drum to E
   Closing valve A
   Opening valve B
   Mid positioning valve C

5. Build up pressure in low side for control setting or to test for leaks by:
   Sealing E with seal cap
   Opening valve A
   Opening valve B
   Back seating then crack open valve C
   Mid positioning valve D
6. Charge oil through the compressor by:
   Connecting oil supply to E
   Opening valve A
   Closing valve B
   Turning valve C all the way out
   Turning valve D all the way in

542. HEAT EXCHANGERS:

To increase the efficiency of operation of larger commercial units and air conditioning comfort cooling installations, a heat exchanger is often mounted in the liquid and suction line. Figure 391.

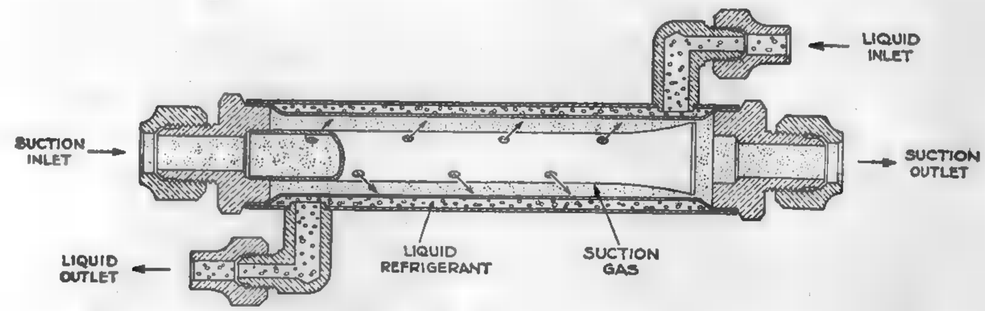


Fig. 391. A heat exchanger
(Courtesy of: Mueller Brass Company)

A heat exchanger, as the name indicates, provides for a heat transfer from the warmer liquid in the liquid line to the cool gas coming from the cooling unit. A study of Figure 318 will show that if the liquid is cooled 10° to 20° F. at the

prevailing head pressure and as it passes through the refrigerant control the liquid can absorb more latent heat as it changes to a gas. The reduction of "flash gas" (vaporized refrigerant which changes instantly from liquid to gas as it passes through the refrigerant control in order to cool the remainder of the liquid refrigerant to the cooling coil temperature) also reduces the pressure drop in the cooling coil. It is essential that the heat exchanger be large enough to allow sufficient heat transfer and it must not restrict the gas flow in the suction line too much. These heat exchangers are rated on B.T.U. capacity of the cooling unit. In installing heat exchangers, in addition to specifying the correct B.T.U. capacity, it is also necessary to obtain the correct fitting size for each tube connection.

543. REPLACEMENT COMPRESSOR SEALS:

As indicated in Paragraph 178, the job of repairing a compressor seal is a very exacting one which frequently requires special tools and is quite time consuming. A normal compressor seal repair requires regrinding and lapping the crankshaft shoulder as well as reservicing the sylphon seal.

Occasionally the labor and material required makes the

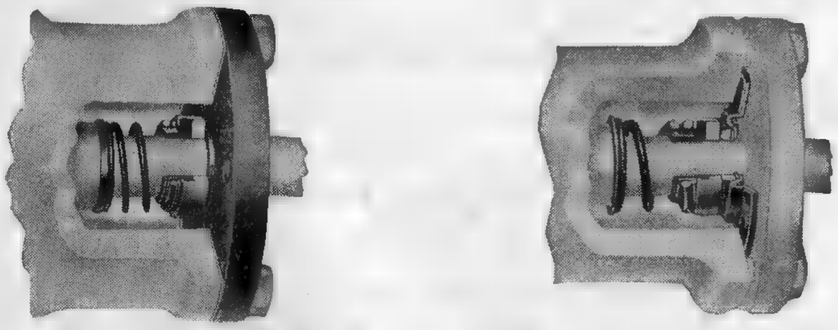


Fig. 392. Two types of replacement seals which eliminate any replacement of compressor shafts or need of machine work
(Courtesy of: Rotary Seal Company)

normal repair impractical and as a result several companies have developed replacement seals that enable a serviceman to quickly and satisfactorily repair such a failure. These replacements can be made on the premises and in a few minutes. Most of these seals use a neoprene gasket to seal a new metal sealing face to the crankshaft and a new contact face is fastened to the compressor body in place of the sylphon seal and seat. Figure 392.

544. LIQUID DRYERS:

Servicemen have been using liquid dryers in considerable quantity with outstanding success during the last few years. These liquid dryers consist of a liquid that has the property to absorb the moisture in the system and make water in a system harmless. In Freon and methyl chloride systems these liquid dryers, which are added to the refrigerant in very small amounts, prevent the freezing of moisture at the refrigerant control. One dryer product is used on the ratio of 1/8 of an ounce per pound of refrigerant.

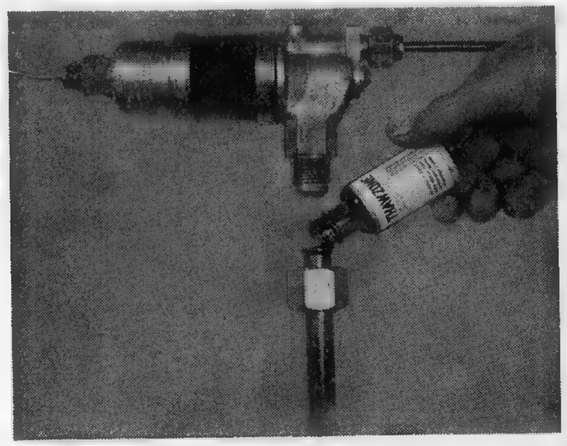


Fig. 393. Adding some liquid dryer to a cooling coil inlet. Only 1/8 ounce of liquid dryer per pound of refrigerant is added
(Courtesy of: Highside Chemicals Company)

As indicated, these fluid dryers are used to remove troubles caused by moisture and so are used in connection with many service operations under conditions in which it is difficult to remove all of the moisture. These fluid dryers also reduce acidic conditions which may result from moisture in a system. It is important to carefully follow the instructions for use which accompany fluid dryers. Figure 393.

CHAPTER XX

SCHOOL REFRIGERATION LABORATORY PROJECTS

The following list of shop jobs has been prepared for school use. It is not intended that this list be completely comprehensive of the work to be covered but rather to give a suggestion of pattern material. The jobs as selected should give a good foundation in refrigeration work in the event time does not permit including additional jobs. The suggested progress chart has been prepared for the convenience of both the teacher and the student. A well-kept progress chart is of assistance to the teacher when making shop assignments. It also gives the student an added incentive to cover as much work as possible and an opportunity for him to know definitely of the progress that he is making.

No.	Name
1	Tube bending
2	Tube flaring
3	Soldering
4	Testing compressors
5	Expansion valves
6	Low side float valves
7	High side float valves
8	Transferring refrigerant from one cylinder to another
9	Removing refrigerant from a system
10	Charging ■ system with refrigerant
11	Domestic pressure motor control
12	Domestic temperature motor control
13	Domestic electric motor
14	Trouble shooting ■ domestic system
15	Pressure water valve
16	Electric water valve
17	Thermostatic expansion valves
18	Two-temperature valves
19	Commercial motor controls
20	Dehydrators, dryers, and neutralizers
21	Installing a water cooler
22	Installing a single dry coil and a single compressor
23	Installing ■ single flooded coil and ■ single compressor
24	Installing multiple dry coils and ■ single compressor
25	Installing multiple flooded coils and ■ single compressor
26	Trouble shooting a multiple flooded system
27	Trouble shooting ■ multiple dry system

SAMPLE PROGRESS CHART FOR THE SCHOOL LABORATORY PROJECTS

Student's Name WM. A. SMITH		Name of Unit Worked On	Date Started and Completed	Job Mark	Write up Mark
Job No.	Name of Job				
1	Tube bending	Bench	4–21 4–22	95%	90%
2	Tube flaring				
3	Soldering				
4	Testing compressors	Kelvinator	4–26 4–29	90%	100%
5	Expansion valves				
6	Low side float valves				
7	High side float valves				
8	Transferring refrigerant from one cylinder to another				
9	Removing refrigerant from a system				
10	Charging a system with refrigerant				
11	Domestic pressure motor control				
12	Domestic temperature motor control				
13	Domestic electric motor				

Job No.	Name of Job	Name of Unit Worked on	Date Started and Completed	Job Mark	Write up Mark
14	Trouble shooting a domestic system				
15	Pressure water valve				
16	Electric water valve				
17	Thermostatic expansion valves				
18	Two-temperature valves				
19	Commercial motor controls				
20	Dehydrators, dryers, and neutralizers				
21	Installing ■ water cooler				
22	Installing ■ single dry coil and a single compressor				
23	Installing ■ single flooded coil and ■ single compressor				
24	Installing multiple dry coils and ■ single compressor				
25	Installing multiple flooded coils and a single compressor				
26	Trouble shooting ■ multiple flooded system				
27	Trouble shooting a multiple dry system				

JOB NO. 1
TUBE BENDING

1. *Purpose:* To become proficient in the manipulation of tubing for installation and repair purposes.

2. *Material:* 1 ¼ inch tubing 5 inches long
   2 ¼ inch tubing 10 inches long
   1 ½ inch tubing 8 inches long
   2 ½ inch tubing 15 inches long

   NOTE.—When processing these pieces, be sure to seal the end of the tubing that is not going to be used.

3. *Tools:* 1 tube cutter
   1 ¼ inch external bending spring
   1 ½ inch external bending spring
   1 12 inch steel rule

4. *Reference:* Read Paragraphs 222, 224, and 225.

5. *Procedure:*

   A. Using the ¼ inch × 5 inch tubing make a 90° bend. These bends must be perfect parts of a circle; use a form such as a pipe or mandril. Use ■ 1¼ inch radius.

   B. Bend the ¼ inch × 10 inch tubing 360°, use a 2½ inch diameter.

   C. Bend the ½ inch × 8 inch tubing 90°, use a 2½ inch radius.

   D. Have the bends checked by the instructor, and the mark recorded on the progress sheet.

   E. Bend the ½ inch × 15 inch tubing 180°, use a 2½ inch radius.

   F. The job write up consists of answering the following:

      1. Why must the tubing which was not used be sealed?

2. When should the sealing of the tubing be done?
3. If the tubing is cut with a hacksaw, what things must be done?
4. What other bending tools besides bending springs may be used?
5. In bending ¼ inch tubing, is a jig needed for ordinary bends? Why?
6. When a sharp bend is made and the bending spring becomes tight on the tubing, how may it be removed?
7. Which is the best, the internal or the external bending spring?
8. The ¼ inch external bending spring can also be used for what other size tubing?
9. What is meant by buckling of the tubing?
10. What are the thicknesses of tubing walls?

JOB NO. 2

TUBE FLARING

1. *Purpose:* To develop the correct technique of making satisfactory and desirable tubing flares.
2. *Material:* 1 ¼ inch O.D. tubing 5 inches long
   1 ½ inch O.D. tubing 5 inches long
   2 ¼ inch flare nuts
   2 ½ inch flare nuts

   NOTE.—When removing these lengths from the original coil, be sure to pinch the coil ends again. The tubing used for the bending exercise may also be used for this job.
3. *Tools:* 1 tube cutter and reamer, or hacksaw with 32 pitch wave set blade
   1 flaring block
   1 flaring spinner or punch
   1 oil can (refrigerant)
4. *References:* Read Paragraphs 222, 223, and 224.

5. *Procedure:*

   A. 1. Ream the ends of the ¼ inch O.D. tubing. (Hold the tubing upside down so the chips will fall out of the tubing.)
      2. Place the nuts on the tubing.
      3. Clamp the tubing in the flaring block correctly. (See Paragraph 224.)
      4. Mount the spinner.
      5. Put some oil on the spinner and tighten down, using an oscillating motion. (Turn forward ¾ turn, then turn back ¼ turn.)
      6. Do not turn the spinner down too tightly as it will thin the flare.

   B. 1. Ream the ½ inch O.D. tubing ends.
      2. Place the nuts on the tubing.
      3. Flare.
      4. Have the job checked and marked by the instructor.

   C. Answer the following:
      1. What is the angle of the flare shoulder?
      2. What organization standardized the flare?
      3. What kind of threads are used on these flared fittings?
      4. Does the tubing need to be reamed? Why?
      5. If the flare splits or cracks, what is wrong?
      6. How may one remedy the above?
      7. What may one do if the flare is too large?
      8. If the flare is too small?
      9. What is meant by the double thickness flare?
      10. Explain the internal nut flare.

JOB NO. 3

SOLDERING

1. *Purpose:* One must acquire the necessary skill to make strong leak-proof soldered joints.

2. *Material:* 1 ½ inch streamline fitting
   1 ½ inch tubing 4 inches long
   1 4 inch square piece of sandpaper
   1 Can of paste flux. (A non-corroding flux is absolutely necessary.)
   1 6 inch length of solder
   1 ⅜ inch O.D. tubing 2 inches long
   2 ¼ inch O.D. tubing 4 inches long
3. *Tools:* 1 gas-oxygen torch, gasoline blow torch, or a soldering iron
   1 pliers (6 inch gas combination)
4. *Reference:* Read Paragraphs 226, 227, and 228.
5. *Procedure:*

A. The streamline joint.
   1. Be sure the ends of the copper tubing are square.
   2. Sand the tubing and the inside of the fitting to a bright finish.
   3. Coat the surface to be soldered with a thin coating of flux.
   4. Join the pieces and heat until solder applied to the filler hole melts.
   5. Continue this until the solder appears at the point of connection between the tubing and fitting. (Solder is only to be applied at the filler hole and this hole must be left filled.)
   6. Cool and show the instructor along with part B.

B. Emergency-soldered joint.
   1. Make a small flare on both ends of the 2 inch piece of ⅜ inch O.D. tubing.
   2. Flare one end of each of the ¼ inch O.D. tubing.
   3. These ¼ inch flares must slide tightly into the ⅜ inch tubing.

   4. Insert them until the two ¼ inch tubing ends meet in the center of the ⅜ inch tubing.
   5. Solder. (Follow all the steps of A.)
   6. No solder or flux must appear inside the ¼ inch pieces of tubing.
   7. Cool.
   8. Have it checked by the instructor along with A.

C. Answer the following as a job report.
   1. What is soft solder made of?
   2. What is hard solder made of?
   3. What is silver solder made of?
   4. Why must the metal be clean before it can be soldered?
   5. What purpose does the flux serve?
   6. What is a good flux for hard and silver soldering?
   7. What parts should be heated to obtain a good soldering job?
   8. What is meant by "wiping" a joint?
   9. What is meant by "tinning" a soldering copper?
   10. What advantage does a streamline joint have over the flared connection?

JOB NO. 4

TESTING COMPRESSORS

1. *Purpose:* To become familiar with some methods of testing and repairing refrigerating compressors.
2. *Material:* 1 pound carbon-tetrachloride
   1 square foot of gasket material
   1 pint of refrigerant oil
   1 can grinding compound (fine, oil-mixed)
   1 wiping cloth
3. *Tools:* 1 ratchet wrench
   1 ½ inch end wrench

1 compound gage
1 hi-pressure gage
1 8 inch adj. end wrench
1 6 inch square of plate glass
1 inside calipers
1 outside calipers
1 steel rule (6 inch)

4. *Equipment:* 1 Reciprocating refrigerating compressor.

5. *References:* Read Paragraphs 175, 176, 177, 178, 164, 394, and 247.

6. *Procedure:*

A. Install the gauges. (BE CAREFUL.)

B. Determine the vacuum the compressor will produce and maintain against a 150 pound per square inch head pressure. The head pressure may be produced by turning the D.S.V. all the way in.

C. Record this value.

D. Remove the compressor if necessary. (ONE MUST LOSE THE MINIMUM OF REFRIGERANT.)

E. Seal all openings with plugs or stoppers.

F. Dismantle the compressor. (MARK EVERYTHING NEATLY TO MAKE SURE YOU ASSEMBLE THE PARTS IN THE CORRECT RELATION TO EACH OTHER. USE A PUNCH OR A FILE. SEE THE SPECIAL INSTRUCTIONS ON HOW TO MARK COMPRESSOR PARTS.)

G. Repair whatever is necessary.

H. Take all the following data:
1. The size of bore and stroke.

2. The size of valve port openings.
3. The size of crankshaft just outside the seal shoulder.
4. The flywheel and pulley diameters.
5. A sketch of the crankshaft seal, the intake and exhaust valve mechanisms.

I. Clean everything *thoroughly* with carbon tetrachloride.

J. Put clean refrigerant oil on the valves, on the seal, and on the piston.

K. Assemble the compressor. (Use new gaskets and oil them.)

L. Put in new oil.

M. Test for efficiency on the compressor testing stand and record.

N. Test for ▪ seal leak by immersing ▪ tube from the D.S.V. into some oil.

O. Install in the system:
1. Vacuate the air
2. Purge
3. Test for leaks

P. Write up the job after having the instructor check and mark your job.

Q. Answer the following:
1. How is an intake valve leak indicated?
2. How is a seal leak indicated?
3. How is an exhaust valve leak indicated?
4. How would a too thick cylinder head gasket affect the operation of the compressor?
5. Why are V belts so popular?
6. Describe the two ways of adding oil.
7. What is the best way to tighten the bolts holding the cylinder heads to the cylinder?

8. What is the seal ring made of?
9. How much vacuum should a compressor in good condition produce against a 150 pound per square inch gauge head pressure?

JOB NO. 5

EXPANSION VALVES

1. *Purpose:* To learn the construction, operation, and repair of automatic expansion valves.

2. *Material:*
   1 ounce glycerine
   1 bottle carbon tetrachloride
   2 ¼ inch plugs (tubing), and 2 ¼ inch caps
   1 wiping cloth

3. *Tools:*
   1 8 inch screwdriver
   1 6 inch adj. wrench
   1 ¾ inch end wrench
   1 1 inch end wrench
   1 ratchet wrench
   1 set of gauges
   1 12 inch steel rule

4. *Equipment:* A refrigerator mechanism using an expansion valve.

5. *References:* Read Paragraphs 45, 88, 166, 181, 186, and 251.

6. *Procedure:*

   A. Test the expansion valve.
      1. To determine if it leaks, turn the adjusting screw all the way out and determine if it will maintain a vacuum. Check the compressor to see if it will hold a vacuum.
      2. See if it will resume its normal pressure after having pulled a vacuum on the low side or after allowing it to build up a pressure on the low side by closing the liquid receiver service valve or stopping the compressor respectively.

   B. Remove the expansion valve from the unit. (BE CAREFUL.)
      1. Remove the refrigerant.
      2. Balance the pressures.
      3. Turn the S.S.V. all the way in.
      4. Clean the outside of the connections before unfastening the valve.
      5. Plug all the openings.

   C. Dismantle the expansion valve. Carefully note where the different parts belong; mark them if necessary.

   D. Clean all the parts with carbon tetrachloride.

   E. Inspect the seat, needle, and screen.

   F. Repair if necessary.

   G. Clean the outside of the bellows or diaphragm.

   H. Determine the following:
      1. The size of the orifice opening.
      2. The size of the diaphragm.
      3. The size and type of the inlet and exhaust fittings.

   I. Assemble the valve.

   J. Wash all the parts very carefully with carbon tetrachloride.

   K. Test the bellows.
      1. Connect the low side to an air line.
      2. Build up a 15 pound per square inch to 20 pound per square inch pressure.
      3. Use oil to test for a leak (bubbles).

L. Test the expansion valve for its ability to hold a 90 pound pressure at the needle.
   1. Connect the liquid line connection to an air line.
   2. Flush the needle by opening the valve.
   3. Test the leaks with refrigerant oil.

M. Have the instructor check and record a mark for the work on the valve.

N. Install it in the system. (BE CAREFUL.)
   1. Purge the system of air.
   2. Test for leaks.
   3. Put glycerine on the outside of the bellows.

O. Run the unit and have the job checked.

P. Write a report on the job answering the following:
   1. How may one increase the low side pressure?
   2. What kind of a motor control is used with an expansion valve?
   3. What is a brine tank cooling unit?
   4. What brines are commonly used?
   5. An expansion valve with the liquid line nut frosting and insufficient refrigeration in the cabinet indicates what trouble?
   6. Of what materials are the needles and seats made?
   7. How is a leaky needle indicated?
   8. Where is the motor control located on the coil? Why?
   9. Why was glycerine put on the outside surface of the diaphragm or bellows?
   10. What is the best way to clean a screen?

JOB NO. 6
LOW SIDE FLOAT VALVES

1. *Purpose:* To become acquainted with the repair and operation of low side float valves.

2. *Material:*
   1 1 pound bottle of carbon tetrachloride
   1 quart of refrigerant oil
   1 wiping cloth
   1 6 inch square of 1/16 inch gasket material

3. *Tools:*
   1 set of gauges
   1 refrigeration ratchet wrench
   1 1 inch end wrench
   1 3/4 inch end wrench
   1 1/2 inch end wrench
   1 spirit level
   1 6 inch screwdriver

4. *Equipment:* 1 refrigerator mechanism equipped with a low side float valve.

5. *Reference:* Read Paragraphs 47, 89, 168, 182, 187, and 250.

6. *Procedure:*

   A. Test the float valve.
      1. A continuous hissing sound in the cooling unit accompanied by a frosted suction line will indicate a leak at the float needle.
      2. Close the R.S.V. for 2 or 3 minutes, then open; if the cooling unit hisses and then stops for a moment, the needle is all right.
      3. Determine if the float needle leaks with a 90 pound liquid line pressure.

   B. Remove the float valve. (BE VERY CAREFUL.)
      1. Remove the refrigerant, balance the pressures, isolate, and clean.
      2. Plug all the openings.

   C. Dismantle the valve.
      1. Clean all the parts (carbon tetrachloride).

2. Record the size of the orifice opening.
3. Make a sketch of the location of the screen.
4. Repair the needle and seat if necessary.
5. Clean the screen if necessary.

D. Assemble the valve.
1. Calibrate and test for leaking.
a) See if the float is level.
b) Test for a needle leak using a 90 pound liquid line air pressure.

E. Have the instructor check the job, and get the mark recorded.

F. Inspect the gasket, if it is necessary, replace.

G. Install the valve in the system. (BE CAREFUL.)

H. Answer the following questions:
1. What is the most popular refrigerant used with low side float valves?
2. What indicates a leaky float valve needle in a system?
3. What is meant by calibrating a float?
4. What is a cartridge needle float valve system?
5. What is oil binding?
6. What metals are the needles and seats commonly made of?
7. How is the ball float proper tested for leaks?
8. Why are lead gaskets commonly used on low side float chamber headers?
9. Why do some systems have servicing valves on the cooling unit?
10. Starting with a warm box, describe the action of the low side pressure as the compressor operates with:
a) Low side float valve.
b) Expansion valve.

JOB NO. 7

HIGH SIDE FLOAT VALVES

1. *Purpose:* To become adept at dismantling and repairing high side float valves.

2. *Material:* 1 1 pound bottle of carbon tetrachloride
1 wiping cloth
1 6 inch square of gasket material

3. *Tools:* 1 set of gauges
1 refrigeration ratchet wrench
1 1 inch end wrench
1 ¾ inch end wrench
1 ½ inch end wrench
1 6 inch screwdriver
1 gasoline torch

4. *Equipment:* 1 refrigerator mechanism equipped with a high side float valve.

5. *Reference:* Read Paragraphs 48, 90, 167, 183, 187, and 250.

6. *Procedure:*

A. Install the gauges.

B. Test the float valve.
1. An uneven frost on the cooling coil indicates a lack of refrigerant.
2. A frosted suction line indicates too much refrigerant.
3. A leaky valve will be indicated by a higher than normal low side pressure.

C. Remove the float valve.
1. Remove the refrigerant, balance the pressures, isolate the float, clean and dry all the connections.
a) Remove the refrigerant from the float chamber by

connecting a line from the float chamber service valve to the S.S.V.

D. Dismantle the valve.
   1. Clean all the parts with carbon tetrachloride.
   2. Inspect all the parts.
   3. Record the size of the orifice opening.
   4. Make a sketch showing the location of the screen.
   5. Repair the needle and seat if it is necessary.

E. Assemble the valve.
   1. Calibrate the float and test as follows:
      a) Determine if the float moves freely.
      b) Determine if the float is lined-up correctly.
   2. Inspect the gasket and if necessary, replace it with a new one.
   3. Test for a needle leak by connecting a 90 pound per square inch dry air pressure to the high pressure connection and testing with oil.

F. Have the instructor check the job and the mark recorded.

G. Install the valve in the system.
   1. Clean and dry all the parts.
   2. Evacuate and purge the system.
   3. Test for leaks.
   4. Start and adjust the unit.

H. Answer the following questions:
   1. How many kinds of high side float systems are used?
   2. Why are some high side float balls made of steel?
   3. How is air in the system indicated in this type of system?
   4. Why may the cooling coil in this high side float system be called a flooded coil?
   5. What will be the low side pressure when the unit is running if the coil temperature is 12°F. using ethyl chloride as the refrigerant?
   6. Why are not separate liquid receivers used on high side float systems?
   7. Name three refrigerators which use a high side float refrigerant control.
   8. Why are high side float chambers sometimes equipped with purging valves?
   9. Why must a high side float hermetic system be carefully leveled?
   10. What would cause a high side float ball to collapse?

JOB NO. 8

HANDLING REFRIGERATORS: CHARGING A SERVICE CYLINDER FROM A STORAGE CYLINDER

1. *Purpose:* To acquire the necessary skill to transfer refrigerants from one container to another safely, cleanly, and economically.

2. *Material:* 3 pound refrigerant

3. *Tools:*
   1 ratchet wrench
   1 1 inch open end wrench
   1 charging tube
   1 leak tester
   1 blow torch
   1 pair goggles

4. *Equipment:*
   1 5 pound refrigerant cylinder
   1 refrigerant storage cylinder

5. *References:* Read Paragraphs 196, 236, and 246.

6. *Procedure:*

   A. Place the full cylinder upside down.

B. Place the empty one right side up. (Hold both of the cylinders firmly.)

C. Connect the two drums by means of the charging tube, leaving the service cylinder connection slightly loose.

D. Crack the storage cylinder valve and then tighten the loose fitting after one can detect the odor of the refrigerant. (This removes all the air and dirt from the charging line.)

E. Open both valves.
   1. Wear a pair of goggles for safety.
   2. Test for leaks.

F. Cool the tank to be filled and heat (very slightly) the tank from which the refrigerant is to flow.

G. Place the tank to be filled on a scale and put in the required amount (1 pound at a time). One may remove the cylinder from the charging line to weigh it or use a long horizontal charging line.

H. Close the storage tank valve.

I. Heat the charging line slightly.

J. Close the valve on the storage cylinder just filled.

K. Remove the charging line.

L. Plug all the connections on the line.

M. Have the instructor check and mark the job.

N. Answer the following questions:
   1. What is the pressure inside a cylinder of sulphur dioxide at 72°F.?
   2. Why must the full cylinder be inverted?
   3. Why is the connecting line purged?

4. Why must one heat the cylinder carefully?
5. Are these cylinders equipped with safety plugs?
6. If a sulphur dioxide cylinder has a 100 pound per square inch pressure at 72°F., what may be wrong?
7. Why must one be careful of the amount of refrigerant put into a cylinder?
8. What harm may liquid refrigerant do to a person's eyes?
9. What care should be given the valve and refrigerant opening to the storage cylinder?
10. Why must the charging line be in excellent condition?

JOB NO. 9

REMOVING REFRIGERANT FROM A SYSTEM: DISCHARGING A REFRIGERATING SYSTEM INTO A CYLINDER

1. *Purpose:* To become acquainted with all the phases of removing refrigerant from a system.

2. *Material:* 1 1 pound bottle of carbon tetrachloride
   1 wiping cloth
   1 6 inch square of gasket material

3. *Tools:* 1 set of gauges
   1 refrigeration ratchet wrench
   1 6 inch square of gasket material
   1 ¾ inch end wrench
   1 ½ inch end wrench
   1 6 inch screwdriver
   1 gasoline torch

4. *Equipment:* 1 refrigerator mechanism equipped with a high side float valve.

5. *Reference:* Read Paragraphs 197 and 236.

6. *Procedure:*

A. Connect the cylinder to the D.S.V. gauge connection by means of a charging line.
   1. The cylinder is to be mounted below the compressor and right-side up.
   2. Use a gauge in the line when this is being done the first time.

B. Purge this line.

C. Turn the D.S.V. all the way in and open the cylinder valve.

D. Place the cylinder in a container full of ice and water.
   1. Do not wet the valves or lines.

E. Run until all the refrigerant or the required amount is removed. (If the back pressure drops to a vacuum, run the compressor intermittently to minimize the chance of oil pumping.)

F. Never allow the head pressure to exceed 100 pounds to the square inch for sulphur dioxide, 135 pounds per square inch for methyl chloride, 175 pounds per square inch for Freon.

G. Turn the D.S.V. all the way out.

H. Heat the charging line a trifle with a torch or by hand friction.

I. Close the cylinder valve and disconnect the line.
   1. Plug all the openings.

J. Have the job checked and marked by the instructor.

K. Answer the following questions:
   1. Why is a gauge connected into the charging line?
   2. Is it always advisable to save the refrigerant?
   3. How is the refrigerant disposed of otherwise?
   4. Why should the head pressure be controlled?

   5. How can one tell when all the refrigerant has been removed?
   6. Why must one be careful about the oil pumping?
   7. What should one do if the liquid receiver starts sweating or frosting during this operation?
   8. If it is a methyl chloride system, what is the best way to test for leaks?
   9. How will one be able to tell when the cylinder becomes full?
   10. Is it necessary to make new flares every time the charging connection is used?

JOB NO. 10

CHARGING A SYSTEM WITH REFRIGERANT: CHARGING A SYSTEM FROM A CYLINDER INTO A REFRIGERATING SYSTEM

1. *Purpose:* To learn the methods of transferring refrigerant into a system.
2. *Material:* 3 pounds refrigerant
3. *Tools:*
   1 ratchet wrench
   1 1 inch open end wrench
   1 charging tube
   1 leak tester
   1 blow torch
   1 pair goggles
4. *Equipment:*
   1 5 pound refrigerant cylinder
   1 refrigerant storage cylinder
5. *Reference:* Read Paragraphs 194, 196, and 236.
6. *Procedure:*

   A. CHARGING INTO THE HIGH PRESSURE SIDE. If all the refrigerant in the cylinder is to be put into the system, proceed as follows:

1. Connect the cylinder to the D.S.V. gauge opening Put a gauge in the charging line using a "Tee" fitting.
2. Purge the line. Test for leaks.
3. Invert the cylinder. Hold upside down and open all the valves.
4. Start up the compressor with the D.S.V. turned all the way in. Do this for only a minute or two. (This is to build up a 150 pound per square inch pressure in the refrigerant cylinder.)
5. Turn the D.S.V. out a turn or two, the high pressure in the cylinder will force all the refrigerant into the condenser and receiver. (Listen for the gurgling in the cylinder and when this stops, either all the refrigerant is out of the cylinder or the pressures have become equalized.)
6. Have the job checked and marked by the instructor.
7. Write up the procedure and precautions.
8. Record the empty weight of the drum and how long it took to empty the cylinder after the valve was opened.

B. CHARGING INTO THE LOW PRESSURE SIDE. A slower but more accurate method of charging a system is as follows:

1. Connect the charged cylinder to the S.S.V. gauge opening by means of a charging line.
   a) Put a gauge in the line using a "Tee" fitting.
   b) The cylinder must be below the compressor and upright.
2. Leave the connection loose at the S.S.V. and purge the charging line.
   a) Test for leaks.
3. Place the cylinder on a scale.
   a) Record the weight.

   b) The charging line must be at least 4 feet long and horizontal to permit accurate weighing.
4. Turn the S.S.V. all the way in.
5. Start the compressor.
   a) Open the cylinder valve (very easily at first).
   b) Never allow the low side pressure to exceed 5 pounds to the square inch for sulphur dioxide. 15 pounds to the square inch for methyl chloride, or 25 pounds per square inch for Freon.
6. Continue this until enough refrigerant has been put into the system.
7. Close the cylinder valve.
8. Balance the pressure, then turn the S.S.V. all the way out.
   a) Disconnect, and plug all the openings.
9. Have the job checked and marked by the instructor.
10. Answer the following questions:
    a) Why must a horizontal charging line be used?
    b) Why should the low side pressure be kept below the recommended limits?
    c) What makes the liquid level visible in the cylinder?
    d) Why does heating the cylinder speed up the removal of the refrigerant?
    e) Why is it dangerous to hold the cylinder inverted when putting the refrigerant into the low side?
    f) What is the gross weight of the cylinder?
    g) What is the tare weight?
    h) Why is carbon tetrachloride better for cleaning than gasolene?
    i) Why is ordinary high pressure air a poor cleaning agent?
    j) Why is charging a system through the low side considered the most accurate way?

JOB NO. 11

DOMESTIC PRESSURE MOTOR CONTROLS

1. *Purpose:* To develop a knowledge of the various constructions, operations, and methods of repairing pressure motor controls.

2. *Material:* 1 tubing connection 15 inches long ¼ inch O.D.
   4 inch square of extra fine sandpaper
   1 can of cleaning fluid

3. *Tools:* 1 6 inch screwdriver
   1 vacuum pump and 1 compound gauge
   1 6 inch adjustable end wrench

4. *Equipment:* A pressure motor control.

5. *Reference:* Read Paragraphs 50, 93, 94, 99, and 100.

6. *Procedure:*

   A. Connect the vacuum pump to the control.
      1. Have the instructor check the hook-up.

   B. Determine the cut-in and cut-out points by means of the vacuum pump.
      1. Record.

   C. Test the bellows for leaks. (Immerse in water under a 10 pounds per square inch to 20 pounds per square inch pressure.)

   D. Determine the range and differential adjustments.
      1. Be able to describe them.

   E. If it is a methyl chloride switch, adjust cut-out to 5 pounds per square inch and cut-in to 17 pounds per square inch.

   F. If it is a sulphur dioxide switch, adjust cut-out to 6 inches of vacuum. Adjust cut-in to 7 pounds per square inch.

   G. Inspect the points for pits and conditions.
      1. Clean if necessary.

   H. Have the instructor check and mark your work.

   I. Make a sketch of the control.

   J. Answer the following questions:
      1. With what types of refrigerant controls is a pressure motor control permissible?
      2. Where is the pressure control usually connected into the system?
      3. What companies make pressure motor controls?
      4. Are pressure controls still used in domestic refrigeration? Why?
      5. What four fundamental steps must be followed in order to remove a pressure control from a system?
      6. What is the pressure inside a sulphur dioxide system bellows if the cooling unit has a temperature of 20°F. with the system running?
      7. How much is the setting changed on the control if the range adjustment is turned one complete turn?
      8. Sketch an electric refrigerator wiring diagram.
      9. What size fuses are used for A.C. ⅙ H.P., ⅕ H.P., and ¼ H.P. motors?
      10. Why is a snap-action switch necessary when open contacts are used?

JOB NO. 12

DOMESTIC TEMPERATURE MOTOR CONTROLS

1. *Purpose:* To learn the operation of temperature motor controls.

2. *Material:* 1 4 inch square of fine sandpaper
   1 5 pounds of water ice

1 2 pounds of calcium chloride
1 can of cleaning fluid

3. *Tools:* 1 4 inch screwdriver
1 6 inch adjustable end wrench
1 pan for the temperature bath
1 thermometer

4. *Equipment:* A temperature motor control.

5. *Reference:* Read Paragraphs 50, 93, 94, 96, 97, 98, 99, 100 and 101.

6. *Procedure:*

A. Determine the cut-in and cut-out temperatures by means of a temperature bath. (Salt, ice and water.)
1. Record.

B. Determine the type of range and differential adjustments.

C. Adjust the cut-in to 25°F. and the cut-out to 15°F.

D. Inspect the points for corrosion and pits.
1. Clean the points if necessary.

E. Have the instructor check and mark the job.

F. Make a sketch of the control.

G. Answer the following questions:
1. What type of motor control is used with an expansion valve system?
2. What are the different types of differential adjustment mechanism?
3. Name some makers of thermostatic controls.
4. What is a toggle?
5. Does the range adjustment adjust the running time or the temperature?

6. Describe three different ways to test a thermostat.
7. What are the bellows charged with?
8. Why must one have a good contact between the thermostatic bulb and the cooling unit?
9. What is an overload cut-out?
10. Sketch a wiring diagram of an electric refrigerator showing a manual switch, a fuse, a motor, and a thermostat.

JOB NO. 18

ELECTRIC MOTORS

1. *Purpose:* To become acquainted with the correct methods of handling electric motors.

2. *Material:* 1 4 inch square of sandpaper
1 quart of cleaning fluid
1 wiping rag

3. *Tools:* 1 6 inch screwdriver
1 6 inch adjustable end wrench
1 automobile oil can
1 Allen set screw wrench
1 steel rule
1 outside calipers

4. *Equipment:* One electric motor.

5. *Reference:* Read Chapter VIII.

6. *Procedure:*

A. Test the motor:
1. See if points or brushes will throw-out.
2. Determine the torque capacity of the motor on the torque stand.
3. Determine the torque when the motor is started.

4. Determine the torque when the motor is running at its full R.P.M.
5. Determine the ampere consumption under both these conditions.
6. Record all of the above.

B. Clean the motor and dismantle. (Mark the parts carefully with a file or a punch.)
1. Inspect the bearings for wear, play, and end play.
2. Clean the commutator if any and see if the brushes are free but not too loose.
3. Clean the contact points if any.
4. Remove all the old oil from the bearings.
5. Put new oil in the bearing receptacles.

C. Assemble the motor, shimming the armature to minimize the end play. (There must be some end play, approximately 1/32 inch.)
1. Mount the pulley.
2. Wire the motor and test again and record as in (A).
3. Connect to the compressor, and line up the belt and motor to the compressor.
4. Run the unit.

D. Have the instructor check and mark the job.

E. Record:
1. The shaft diameter.
2. The wiring hook-up.
3. The specifications.

F. Answer the following:
1. How much current should the motor consume?
2. Sketch a 220 V. hook-up to a 110-220 V. 60 cycle repulsion start induction motor.
3. What is the magnetic center of the armature?

4. What is an induction motor?
5. How may one determine if a bearing is too tight? Too loose?
6. What is a starting winding in an induction motor?
7. Why do most refrigeration motors need special starting devices?
8. What size wire should be used for ¼ H.P. A.C. motor electrical hook-ups?
9. What is an Allen set screw?
10. How warm in °F. is a motor permitted to become?

JOB NO. 14

TROUBLE SHOOTING IN A DOMESTIC SYSTEM

1. *Purpose:* Inasmuch as all refrigerator service work must start with first locating the trouble, the method of trouble shooting in component parts of a refrigerator mechanism is of primary importance.

2. *Material:*
1 1 pound bottle of glycerine
1 can of refrigerant oil
1 can of automobile oil
1 purging line
1 1 pound bottle of carbon tetrachloride
1 wiping cloth

3. *Tools:*
1 compound gauge
1 high-pressure gauge
1 refrigeration ratchet wrench
1 1 inch open end wrench
1 ½ inch open end wrench
1 8 inch adjustable wrench
1 6 inch screwdriver
1 6 inch thermometer

4. *Equipment:* One complete domestic refrigerating mechanism.

5. *Reference:* Read Paragraphs 211, 212, 213, 214, 215, 216, and 217.

6. *Procedure:*

A. Install the gauges, being very careful not to allow the pressures to enter the gauges too rapidly. (Loosen the packing nuts and use only the correct wrenches.)

B. Measure the flywheel and pulley diameters.

C. Record the pressures after the unit has run for approximately 15 minutes.

D. Check the tightness and alignment of the belt. (Record.) Oil the motor bearings with automobile oil if necessary.

E. Clean the condenser and the servicing valves.

F. Determine the trouble with the unit, if any, and record.
   1. Repair the trouble using the methods recommended in the previous job sheets.
   2. Record the method of repair.

G. Record the complete specifications of the refrigerator as found on the various name plates.

H. Record the new pressures and the cooling unit temperatures after the adjustments have been made.

I. Have the job checked and marked by the instructor.

J. Store all the refrigerant in the liquid receiver and condenser.
   1. Close the L.R.S.V. and turn the D.S.V. all the way in.

K. Remove the gauges.

L. Answer the following questions:
   1. What is the compressor speed?

   2. What is the first major servicing operation when starting a new job?
   3. What can the suction line temperature reveal?
   4. What does a hot liquid line indicate?
   5. Why do some of the companies use a flat compressor flywheel on their recent models?
   6. What are the cycling periods for average refrigerators?
   7. How long should it take to form ice cubes?
   8. What is the best box temperature?
   9. Why cannot the box temperature be the same all over the cabinet?
   10. What is defrosting?

JOB NO. 15

PRESSURE WATER VALVES

1. *Purpose:* To learn about the pressure valves used to regulate the water flow through the condenser and the cylinder heads.

2. *Material:*
   1 can grinding compound
   1 can of cleaning fluid
   1 4 inch square sheet sandpaper (fine)
   1 wiping cloth

3. *Tools:*
   1 8 inch adjustable wrench
   1 6 inch screwdriver
   1 refrigeration ratchet wrench
   1 thermometer
   1 high pressure gauge

4. *Reference:* Read Paragraphs 285, 286, 287, 308, 310, 399, 400, 401, 402, 403, 404, and 405.

5. *Equipment:* One water-cooled condensing unit with a pressure controlled water valve.

6. *Procedure:*

A. Start the unit, and after 15 minutes of running determine the inlet and outlet water temperatures. (Record.)

B. Stop the unit and remove the water valve.
   1. Turn the S.S.V. all the way in.
   2. Balance the pressure in the compressor.
   3. Turn the D.S.V. all the way in.
   4. Remove the valve and plug all the openings.
   5. One may also pinch the line (not recommended).
   6. Do not point the refrigerant opening of the valve toward anyone as it may spray refrigerant unexpectedly.

C. Clean the valve.
   1. Inspect the seat, valve, and the screen.
   2. Determine how to adjust the water flow.

D. Assemble the control carefully and install in the system.

E. Start the unit and adjust it to the correct opening pressure according to the water temperature and to the kind of refrigerant.
   1. Determine the change produced by one complete turn of adjustment.
   2. Determine if the water will shut off after the unit has stopped. (Wait at least 5 minutes.)

F. Record the temperatures and sketch the inside of the valve.

G. Have the installation checked and marked by the instructor.

H. Answer the following questions:
   1. In a sulphur dioxide pressure control, at what pressure should the valve open with a water temperature of 70°F.?

   2. What are two advantages of a pressure control?
   3. Why do these systems above have a high pressure motor control?
   4. State the two most common troubles encountered with water valves.
   5. Describe the two types of water-cooled condensers.
   6. What winter precautions must sometimes be taken with water-cooled condensers?
   7. How is the cost of the water consumption offset?
   8. Why must one be careful as to the locality where a water-cooled installation may be made?
   9. How much is the opening pressure affected by one turn of the adjustment?
   10. Why must the water flow stop when the unit stops?

JOB NO. 16

ELECTRIC WATER VALVES

1. *Purpose:* To learn to manipulate electric water valves.
2. *Material:*
   1 roll friction tape
   1 4 inch sandpaper
   1 wiping cloth
   1 can of cleaning fluid
3. *Tools:*
   1 8 inch adjusting wrench
   1 thermometer
   1 6 inch screwdriver
   1 side-cutting pliers
4. *Reference:* Read Paragraphs 285, 286, 287, 308, 309, 399, 400, 401, 402, 403, 404, and 405.
5. *Equipment:* One water-cooled unit with an electric water valve.
6. *Procedure:*

A. Start the unit and after 15 minutes of running determine and record the water inlet and outlet temperatures.

B. Disconnect the water valve and dismantle it.
   1. Do not leave any uncovered wires.
   2. Clean the parts and screen.
   3. Inspect the valve and seat and repair them if necessary.

C. Reassemble the valve and install it back into the unit.

D. Run the unit for 15 minutes and determine the water inlet and outlet temperatures.
   1. Record the temperatures.

E. Have the job checked and marked by the instructor.

F. Answer the following questions:
   1. What is one advantage of an electric control?
   2. What are two disadvantages of the electric valve?
   3. How much electricity does an electric water valve consume?
   4. On what principle does the valve work?
   5. Does the water pressure tend to force the valve closed or open?
   6. Draw a wiring diagram of an electric water valve hook-up.
   7. What is a by-pass type electric water valve?
   8. What causes water valve chatter?
   9. What may be wrong if an electric water valve allows too much water flow?
   10. What materials are used to seal water line joints?

JOB NO. 17

THERMOSTATIC EXPANSION VALVES

1. *Purpose:* To study the operation of the valve which permits the use of dry cooling coils in multiple installations.

2. *Material:*
   1 flange gasket
   1 bottle of glycerine
   1 wiping cloth
   1 pound of ice

3. *Tools:*
   1 thermometer
   1 ½ inch open end wrench
   1 8 inch adjustable wrench
   1 8 inch screwdriver
   1 compound gauge
   1 valve ratchet wrench

4. *Equipment:* One commercial unit with a thermostatic expansion valve.

5. *Reference:* Read Paragraphs 298, 379, 380, and 413.

6. *Procedure:*

   A. Start the unit and note the low side pressure after the unit has run 20 minutes. Also note the temperature at that point where the power element is located.

   B. Remove the expansion valve.
      1. Remove the refrigerant.
      2. Balance the pressure.
      3. Isolate that part.
      4. Clean and dry the connections.
      5. Plug all openings immediately.

   C. Dismantle the valve.
      1. Remove the power element from the body of the expansion valve. (Be careful not to allow the bellows to blow up.)
      2. Clean everything, including the screen.
      3. Inspect the needle and seat and repair them if necessary if removable.

4. Check for moisture in the bellows of the valve. Wash it out thoroughly with carbon tetrachloride.
5. Measure the size of the orifice opening, the diameter of the sealing diaphragm and the diameter of the power element bellows.

D. Assemble the valve. (Be careful.)
1. Put some glycerine in the bellows chamber. (Not in the refrigerant passages!)

E. Test the valve.
1. Connect it to an air line.
2. Put the power element in an ice and water bath.
3. Test the needle with oil against a 90 pound air pressure.

F. Mount it into the system using a new gasket.
1. Remove the air.
2. Purge the lines.
3. Test for leaks.
4. Start the unit and after running it for 20 minutes, record the low side pressure and the temperature at the power element location.

G. Have the job checked and marked by the instructor.

H. Answer the following questions:
1. Why is it important to locate the power element in the proper place?
2. What does the thermostatic expansion valve control on the unit? the pressure? the temperature? or the quantity of refrigerant?
3. What would happen if a sulphur dioxide power element lost its charge:
   a) Ice cream installation.
   b) Walk-in cooler installation.
4. Describe the location of the screen.

5. How would you test the needle and seat for leaks after assembly?
6. Where should the power element be located in a water-cooling sweet water bath?
7. Why do the suction lines sweat or frost a trifle when the compressor first starts up?
8. What would happen if the power element were located in a warm air stream?
9. Can more than one thermostatic expansion valve be used on one cooling unit?
10. What kind of a motor control is commonly used with the thermostatic expansion valve?

JOB NO. 18

TWO-TEMPERATURE VALVES

1. *Purpose:* To learn the operating principles, the adjustments, and the repair of the suction line pressure control valves that are used in multiple temperature installations.

2. *Material:* 1 1 pound bottle carbon tetrachloride
   1 wiping cloth

3. *Tools:* 1 1 inch open end wrench
   1 refrigerant oil can
   1 set of gauges
   1 6 inch screwdriver
   1 8 inch adjustable end wrench

4. *Equipment:* 1 two-temperature valve
   1 refrigerating mechanism

5. *Reference:* Read Paragraphs 302, 303, 304, 305, 306, 386, and 414.

6. *Procedure:*
   A. The metering type of valve. (i.e., it has no differential, it is a throttling valve.)

1. Dismantle the valve.
   a) Notice the location of the various parts.
2. Clean the parts thoroughly with carbon tetrachloride.
3. Record the size of the valve opening.
4. Record the size of the diaphragm or bellows.
5. Assemble the valve carefully. (Be careful not to injure the bellows.)
6. Record the size of the refrigerant openings, labeling each opening.
7. Test the needle and the valve joints for leaks.
   a) Connect the higher pressure coil opening into an air line having between 5 pounds per square inch to 20 pounds per square inch pressure.
   b) Test the joints and the valve body for leaks using the refrigerant oil to do this.
   c) Adjust the valve to open and close at a pressure suitable for use in a water cooler and an ice cream cabinet system using sulphur dioxide as the refrigerant.
8. Record the exact adjustment obtained. Have it O.K.'d.
9. Install it in a multiple system as described in Job No. 25.
10. Have the job checked and marked by the instructor.

B. The snap-action type of valve (i.e., to control the amount of cold produced as well as the low side pressure in a multiple coil).
   1. Repeat the dismantling, cleaning, and data recording of Part A.
   2. Assemble the valve carefully.
   3. Test the needle and the valve connections for leaks.
      a) Connect the small coil opening to an air line having between 5 pounds per square inch to 20 pounds per square inch.

   b) Test the needle and valve for leaks as above.
   c) Adjust the cut-in and cut-out to pressures corresponding to a methyl chloride water cooler and an ice cream cabinet system.
   4. Record the exact adjustment obtained. Have it O.K.'d.
   5. Install it in a multiple system as above.
   6. Have the job checked and marked by the instructor.

C. Answer the following questions:
   1. Where is a two-temperature, metering valve most commonly used?
   2. Where may a two-temperature, snap-action valve be used?
   3. Where should one locate the check valve sometimes used with one of these controls?
   4. What is the purpose of the check valve?
   5. What is the purpose of a surge tank as used in these systems?
   6. If one of these valves leaked, what would be the result?
   7. How should the warm coil and the cold coil be proportioned according to capacity?
   8. What is the differential of the snap-action valve, in pounds per square inch?
   9. How may one adjust a metering valve when it is installed in ■ system?
   10. Sketch ■ snap-action valve installation.

JOB NO. 19

COMMERCIAL MOTOR CONTROLS

1. *Purpose:* To become adept at manipulating motor controls of the commercial type.
2. *Material:* 1 4 inch sheet of ½ sandpaper
   1 wiping cloth
   1 1 pound bottle of cleaning fluid

3. *Tools:* 1 4 inch screwdriver
1 set of gauges
1 refrigeration ratchet wrench
1 ¾ inch open end wrench
1 1 inch open end wrench

4. *Equipment:* 1 commercial pressure control with a high pressure safety cut-out
1 commercial refrigerating system

5. *Reference:* Read Paragraphs 299, 300, 301, and 396.

6. *Procedure:*

A. Examine the control and determine the differential and range adjustments. (Understand them thoroughly.)

B. Examine the points, if any, and show them to the instructor, give him your opinion as to whether or not they are O.K.
1. Sand the points if it is necessary.

C. Examine and record whether the toggle knife edges show signs of wear.

D. Connect the control into the refrigerating system, the high side only, and determine at what pressure the safety control shuts off the motor.
1. This pressure must be built up slowly.
2. Adjust this control to cut-out at 90 pounds per square inch for sulphur dioxide, 125 pounds per square inch for methyl chloride, or 150 pounds per square inch for Freon.

E. Connect the low side to a vacuum pump with a compound gauge in the hook-up.
1. Determine the cut-in and cut-out values.

2. Determine the effect of one complete turn of the range and differential.
3. Record the above.
4. Adjust the cut-in and cut-out points to:
5 pounds per square inch to 6 inches of vacuum for sulphur dioxide
18 pounds per square inch to 6 pounds per square inch for methyl chloride
13 pounds per square inch to 27 pounds per square inch for Freon

F. Show the job to the instructor to be graded.

G. Answer the following questions:
1. On what type of system is the high pressure safety cut-out most commonly found?
2. What is the purpose of the high pressure cut-out?
3. Will a partly pinched high pressure line to the control affect its operation?
4. What must one be careful about when removing the high pressure control line from the system?
5. Where is the commercial motor control usually located?
6. If the job were an ice cream cabinet, what would the pressures be if sulphur dioxide were the refrigerant?
7. If the job were a water cooler, what would the pressures be if methyl chloride were the refrigerant?
8. Where should the low side control be connected into the system?
9. Are the pressures the same all the way through the low side?
10. If the unit short cycles, list the possible control troubles.

JOB NO. 20

DEHYDRATORS, DRYERS, AND NEUTRALIZERS

1. *Purpose:* To become acquainted with the methods of charging and installing dehydrators and neutralizers.

2. *Material:* 1 pound C.P. calcium chloride
   1 bottle carbon tetrachloride

3. *Tools:* 1 ¾ inch end wrench
   1 8 inch pipe wrench
   1 oil can (refrigerant)

4. *Reference:* Read Paragraph 409.

5. *Equipment:* A dehydrator and a refrigerating system.

6. *Procedure:*

   A. Dismantle the dryer.
      1. Record the size of the fittings.
      2. Make a sketch of the interior.
      3. Clean the interior thoroughly.
      4. Charge the dryer 60 per cent full with calcium chloride.

   B. Assemble the unit carefully.
      1. Test for leaks by putting it in an air line and creating a 90 pound per square inch head pressure.
      2. Test to determine if air will flow through the dryer.

   C. Mount the dryer in the system.
      1. Remove the refrigerant from the liquid line.
      2. Balance the pressure in the line.
      3. Isolate the line.
      4. Clean the joints before disconnecting.
      5. Purge the line upon assembly.
      6. Test for leaks.
      7. Leave it in the system for 20 minutes.

   D. Remove the dryer from the system. (BE CAREFUL.)
      1. Plug the dryer.
      2. Test the connections in the system for leaks.

   E. Answer the following questions:
      1. Name some other dryer chemicals.
      2. What is a neutralizer?
      3. Can one use a dryer on a sulphur dioxide system?
      4. What does moisture do to a methyl chloride system?
      5. How long should a calcium chloride dryer be left in the system?
      6. What does moisture do to a Freon system?
      7. How full should the dryer be packed?
      8. What is a master screen and where is it usually placed?

JOB NO. 21

INSTALLING A WATER COOLER

1. *Purpose:* To become familiar with water cooling problems.

2. *Material:* 1 refrigerant oil can
   1 hand water valve
   50 feet ⅜ inch copper tubing
   1 can Litharge
   1 bottle glycerine
   25 feet extension cord; necessary fittings
   1 wiping cloth

3. *Tools:* 1 set of gauges
   1 refrigeration ratchet wrench
   1 ¾ inch end wrench
   1 1 inch end wrench
   1 flaring outfit
   1 ¼ inch tube bender
   1 ½ inch tube bender

4. *Reference:* Read Paragraphs 277, 293, 294, 295, 370, 374, 375, 377, 378, and 380.

5. *Procedure:*

A. Determine the location of the water cooler.

B. Install the water-in and water-out lines.
   1. Use 3/8 inch copper tubing.
   2. Run the tubing horizontally or vertically making neat bends at the corners.
   3. Fasten the tubing to the wall, at 4 foot intervals.
   4. Install a water shut-off valve between the water-in tubing and cooling coil.
   5. Check the water circuit for water leaks.
   6. Record the water temperature.
   7. Record the water temperature desired.

C. Record the type of cooling coil.

D. Start the unit.
   1. Install gauges.
   2. Test for leaks.
   3. Record the motor control setting and adjust it to the correct setting, record.

E. Have this data O.K.'d by the instructor.

F. Open the water valve.

G. Record the water temperatures after 20 minutes of operation.

H. Answer the following questions:
   1. What is the temperature difference between the refrigerant and the water when the unit is running?
   2. What is a sweet water bath?
   3. How cold may the refrigerant become in a non-brine water cooler?

   4. What is the purpose of an ice hold-over?
   5. Where is an ice hold-over produced?
   6. Calculate the heat removed from 20 gallons of water for the temperature change produced in the system.
   7. How thick is ice water cork insulation?
   8. How cold may water be when it is to be consumed by theater goers?
   9. What is a circulating water multiple fountain installation?
   10. May ■ water cooler be connected in multiple to ■ grocery cabinet or to ■ restaurant cabinet?

JOB NO. 22

INSTALL A SINGLE DRY COIL SINGLE COMPRESSOR SYSTEM

1. *Purpose:* To become proficient in assembling remote refrigerating apparatus.

2. *Material:*
   - 50 feet 1/4 inch tubing
   - 50 feet 1/2 inch tubing
   - 25 feet super service extension cord
   - 2 1/4 inch flare nuts
   - 2 1/2 inch flare nuts
   - 6 1/2 inch pipe straps
   - 1 roll friction tape

3. *Tools:*
   - 1 set gauges
   - 1 flaring outfit
   - 1 refrigerant oil can
   - 1 ball pein hammer
   - 1 1/4 inch bending spring
   - 1 1/2 inch bending spring
   - 1 3/4 inch end wrench
   - 1 1 inch end wrench
   - 1 8 inch adjustable end wrench

1 refrigeration ratchet wrench
1 6 inch screwdriver
1 leak detector
1 purging line

4. *Reference:* Read Paragraphs 150, 151, 153, 375, 378, 379, and 380.

5. *Equipment:* 1 condensing unit
1 cooling coil
1 cabinet
1 refrigerant control
1 motor control

6. *Procedure* (this is a non-code installation):

A. Determine the location for the condensing unit and cooling coil.

B. Install the condensing unit and cooling coil:
1. Fasten the condensing unit firmly to the floor.
2. Mount the cooling coil in the cabinet securely and so that it is level in all directions.
3. Sketch the baffle arrangement.
4. Record the manufacturer's name and style of both the cooling coil and the condensing unit.

C. Install the suction line:
1. Connect it first to the cooling coil and install in such a way that the tubing is as straight as possible.
2. Run the tubing along the wall horizontally or vertically and make neat bends at all corners using the ½ inch bending spring for this purpose. (The radius of this bend should not be less than 2½ inches.) Do not put any 360 degree bends or loops in the tubing except where the suction line is connected to the compressor.
3. Record the number of feet of tubing used.

D. Install the liquid line:
1. Connect the line to the cooling coil.
2. Run the tubing along the suction line. Tape the two lines together at points approximating 4 feet apart and fasten these points to the wall using ½ inch pipe straps.
3. Put a 360 degree horizontal loop in the liquid line before fastening it to the liquid receiver.

E. Evacuate as follows:
1. Leave the suction line loose at the condensing unit.
2. Turn the refrigerant control adjusting screw all the way in.
3. Crack the liquid receiver service valve until all the air is removed (odor).
4. Test for leaks using a 30 pounds per square inch pressure.
5. Turn the refrigerant control adjusting screw out.

F. If the system has a water-cooled condenser, the following must be done before the system is started:
1. Connect water-in and water-out lines to the unit as described in Jobs Nos. 15 and 16.
2. Use ⅜ inch tubing.
3. Test for water leaks.
4. Determine the water valve adjustment and record.
5. Turn the water on before starting the condensing unit.

G. Start the unit and open the service valves:
1. Record the pressures in the system after 20 minutes of operation.
2. Record the water-in and water-out temperatures if it is a water-cooled system.

H. Answer the following questions:
1. Why must the opening through which the tubing enters the cabinet be sealed?

2. Why is the suction line installed prior to the installation of the liquid line?
3. Why is it necessary to mount the coils in the cabinet in a level position?
4. Why must the water be turned on before starting a water-cooled unit?
5. Why are horizontal loops preferable to vertical loops in the refrigerant lines?
6. Why must one turn the refrigerant control adjustment out before starting a dry system?
7. What is the probable trouble if the suction line starts to frost when the unit is started in a dry system?
8. Why is friction tape used as a shield between the pipe straps and the tubing?
9. What must be done to safeguard flared connections on the cooling coil?
10. What may be done to neutralize sulphur dioxide fumes when purging?

JOB NO. 28

INSTALL A SINGLE FLOODED COIL SINGLE COMPRESSOR SYSTEM

1. *Purpose:* To become proficient in assembling remote refrigerating apparatus.

2. *Material:*
   - 50 feet 1/4 inch tubing
   - 50 feet 1/2 inch tubing
   - 25 feet super service extension cord
   - 2 1/4 inch flare nuts
   - 2 1/2 inch flare nuts
   - 6 1/2 inch pipe straps
   - 1 roll friction tape

3. *Tools:*
   - 1 set gauges
   - 1 flaring outfit

   - 1 refrigerant oil can
   - 1 ball pein hammer
   - 1 1/4 inch bending spring
   - 1 1/2 inch bending spring
   - 1 3/4 inch end wrench
   - 1 1 inch end wrench
   - 1 8 inch adjustable end wrench
   - 1 refrigeration ratchet wrench
   - 1 6 inch screwdriver
   - 1 leak detector
   - 1 purging line

4. *Reference:* Read Paragraphs 150, 151, 153, 375, 378, 379, and 380.

5. *Equipment:*
   - 1 condensing unit
   - 1 cooling coil
   - 1 cabinet
   - 1 refrigerant control
   - 1 motor control

6. *Procedure* (this is a non-code installation):

   A. Determine the location for the condensing unit and cooling coil.

   B. Install the condensing unit and cooling coil:
      1. Fasten the condensing unit firmly to the floor.
      2. Mount the cooling coil in the cabinet securely and so that it is level in all directions.
      3. Sketch the baffle arrangement.
      4. Record the manufacturer's name and style of both the cooling coil and the condensing unit.

   C. Install the suction line:
      1. Connect it first to the cooling coil and install in such a way that the tubing is as straight as possible.

2. Run the tubing along the wall horizontally or vertically and make neat bends at all corners using the ½ inch bending spring for this purpose. (The radius of this bend should not be less than 2½ inches.) Do not put any 360 degree bends or loops in the tubing except where the suction line is connected to the compressor.
3. Record the number of feet of tubing used.

D. Install the liquid line:

1. Connect the line to the cooling coil.
2. Run the tubing along the suction line. Tape the two lines together at points approximately 4 feet apart and fasten these points to the wall using ½ inch pipe straps.
3. Put a 360 degree horizontal loop in the liquid line before fastening it to the liquid receiver.

E. Evacuate as follows:

1. Leave the liquid line connection loose at the cooling coil.
2. Crack the liquid receiver service valve.
3. Tighten the liquid line connection at the cooling coil.
4. Leave the suction line connection loose on the condensing unit.
5. Crack the suction line service valve on the cooling coil until all the air is removed (odor).
6. Tighten the connection at the condensing unit.
7. Test for leaks using a 30 pounds per square inch pressure.
8. This procedure should remove practically all the air from the two lines.

F. If the system has a water-cooled condenser, the following must be done before the system is started:

1. Connect water-in and water-out lines to the unit as described in Jobs Nos. 15 and 16.
2. Use ⅜ inch tubing.
3. Test for water leaks.
4. Determine the water valve adjustment and record.
5. Turn the water on before starting the condensing unit.

G. Start the unit and open the service valves:

1. Adjust the refrigerant control.
2. Record the pressures in the system after 20 minutes of operation.
3. Record the water-in and water-out temperatures if it is a water-cooled system.

H. Answer the following questions:

1. How may the air be removed from the suction line in a low side float system if the coil does not have a charge of refrigerant?
2. If the suction line frosts when the unit is started in a flooded system, what is the probable trouble?
3. Why are the liquid and suction lines purged separately?
4. Describe how the coil is mounted in the cabinet.
5. What is the purpose of the baffle?
6. Is the cold air flue larger or smaller than the warm air flue?
7. If a temperature motor control is used, how is the control connected into the electrical hook-up?
8. Was the coil installed as a frosting, defrosting, or a nonfrosting coil?
9. How is the baffle drained?
10. How would the unit be installed if the low side float was not equipped with service valves?

JOB NO. 24

INSTALL A DRY MULTIPLE COIL, SINGLE COMPRESSOR SYSTEM

1. *Purpose:* To become proficient in the installing of multiple system of refrigerating equipment.

2. *Material:*
   - 50 feet ¼ inch tubing
   - 50 feet ½ inch tubing
   - 25 feet super service extension cord
   - 2 ¼ inch flare nuts
   - 2 ½ inch flare nuts
   - 6 ½ inch pipe straps
   - 1 roll friction tape

3. *Tools:*
   - 1 set gauges
   - 1 flaring outfit
   - 1 refrigerant oil can
   - 1 ball pein hammer
   - 1 ¼ inch bending spring
   - 1 ½ inch bending spring
   - 1 ¾ inch end wrench
   - 1 1 inch end wrench
   - 1 8 inch adjustable end wrench
   - 1 refrigeration ratchet wrench
   - 1 6 inch screwdriver
   - 1 leak detector
   - 1 purging line

4. *Reference:* Read Paragraphs 369-88.

5. *Equipment:*
   - 2 cooling coils
   - 2 cabinets
   - 1 condensing unit
   - 2 thermostatic expansion valves
   - 1 ½ inch hand operated service valve
   - 1 ¼ inch hand operated service valve
   - 1 dehydrator

6. *Procedure:*

   A. Install the tubing as prescribed in Job No. 22.
      1. At the point where the suction lines of the coils meet, a hand operated service valve must be installed to control one of the coils.
      2. The same procedure is to be followed for the liquid lines.

   B. Remove the air from the system as follows:
      1. Close the hand valve.
      2. Loosen the suction line connection on the compressor.
      3. Crack the L.R.S.V.
      4. Tighten the suction line connection on the compressor when refrigerant starts to come out (odor). This will remove the air from the cooling coil not controlled by the hand valves.
      5. Loosen the suction line connection coming from the hand controlled cooling coil on this hand valve.
      6. Crack the liquid line hand valve.
      7. Tighten the suction line connection when the refrigerant starts to escape.

   C. Test the system for leaks:
      1. Build up a 30 to 40 pound per square inch pressure in the parts of the system to be tested.

   D. Start the unit using the instructions outlined in Job No. 23.

   E. Record pressures and temperatures of both coils after 20 minutes of operation.

   F. Sketch the installation.

   G. Have the job checked by the instructor.

H. Answer the following questions:
1. May the compressor be used to evacuate all the lines before they are purged?
2. When is a dehydrator installed on a system of this nature?
3. Where is the dehydrator installed?
4. May hand operated valves be installed for both cooling coils?
5. Why are the ends of the conduit in code installation sealed?
6. Does purging a system remove all of the air?
7. Why is tin coated tubing preferred inside refrigerator cabinets?
8. What is a frost-proof unit?
9. Why should suction lines always be slanted downward toward the condensing unit?
10. What is the purpose of an oil separator, and when is it installed?

JOB NO. 25

INSTALL A MULTIPLE FLOODED COIL, SINGLE COMPRESSOR SYSTEM

1. *Purpose:* To become proficient in the installing of multiple system of refrigerating equipment.

2. *Material:*
50 feet ¼ inch tubing
50 feet ½ inch tubing
25 feet super service extension cord
2 ¼ inch flare nuts
2 ½ inch flare nuts
6 ½ inch pipe straps
1 roll friction tape

3. *Tools:*
1 set gauges
1 flaring outfit

1 refrigerant oil can
1 ball pein hammer
1 ¼ inch bending spring
1 ½ inch bending spring
1 ¾ inch end wrench
1 1 inch end wrench
1 8 inch adjustable end wrench
1 refrigeration ratchet wrench
1 6 inch screwdriver
1 leak detector
1 purging line

4. *Reference:* Read Paragraphs 369-88.

5. *Equipment:*
2 low side float cooling coils
2 cabinets
1 condensing unit
1 pressure motor control
1 ½ inch hand operated service valve
1 ¼ inch hand operated service valve

6. *Procedure:*

A. Install the tubing as prescribed in Job No. 23.
1. At the point where the suction lines of the coils meet, a hand operated service valve must be installed to control one of the coils.
2. The same procedure is to be followed for the liquid lines.

B. Remove the air from the refrigerant lines as follows:
1. Close the hand valves located at the junctions of the suction and liquid lines. Leave the suction line connection loose that the hand valve controls. Crack the suction line valve located on the coil, then tighten the connection on the hand valve after the air has been purged.

2. Do the same for the liquid line.
3. Purge the suction line running from the compressor up to the coil not equipped with the hand shut-off valve by leaving the connection loose at the suction service valve and cracking the service valve on the coil.
4. Repeat the above for the liquid line.

C. Test the system for leaks.
1. Build up a 30 to 40 pound per square inch pressure in the parts of the system to be tested.

D. Start the unit using the instructions outlined in Job No. 23.

E. Record pressures and temperatures of both coils after 20 minutes of operation.

F. Sketch the installation.

G. Have the job checked by the instructor.

H. Answer the following questions:
1. Why must one of the two coils be provided with hand operated service valves?
2. Why must these hand operated service valves be mounted on some stationary object?
3. What will be the relative pressures in the two coils while the compressor is running in the following conditions?
a) If the suction lines are of equal length and equal size.
b) If the one coil has a suction line twice as long as the other but of equal diameter.
c) If one coil uses a $\frac{3}{8}$ inch suction line while the other uses a $\frac{1}{2}$ inch suction line but of equal length.

4. How may one detect a leaky refrigerant control needle in a multiple flooded installation?
5. What changes would have to be made in the installation just completed if it were to be done according to the recommended code?
6. What is the size of thin wall conduit used in most of the code installations?
7. What is Greenfield tubing?
8. How is thin wall conduit fastened to the steel box valve containers?
9. What is a refrigerant tubing manifold system?
10. List some tests to be met in code ordinances before a unit may be O.K.'d for running.

JOB NO. 26

TROUBLE SHOOTING ON A MULTIPLE FLOODED SYSTEM

1. *Purpose:* To become adept in locating refrigerating troubles.
2. *Material:* 1 6 inch square of fine sandpaper
1 clean wiping cloth
3. *Tools:* 1 set of gauges
1 refrigeration ratchet wrench
1 $\frac{3}{4}$ inch end wrench
1 1 inch end wrench
1 $\frac{1}{2}$ inch end wrench
1 8 inch adjustable end wrench
1 6 inch screwdriver
1 bottle of aqua ammonia or
1 halide leak detector
torch
4. *Reference:* Read Paragraphs 393-422.
5. *Equipment:* One commercial refrigerating system using two or more low side float coils.

6. *Procedure:*

A. Install the gauges.
   1. Record the pressures of the system.

B. Record the temperatures of the coils after 20 minutes of operation.

C. Check the condensing unit:
   1. Check the belt alignment and the motor bearing oil.
   2. Check the condensing water flow if it is a water-cooled unit.
   3. Record the in and out temperatures of the water.
   4. Record the opening pressure of the water valve.
   5. Clean the condensing unit.

D. Determine the relative temperatures of the liquid and suction lines 1 foot away from the cooling coils and record.

E. Record the sound of the refrigerant control.

F. Record which parts of the condenser and the receiver are warm and which parts cold. Be very exact as to where the dividing line is located.

G. Record the condition of the compressor as to pumping ability and sound:
   1. If it is a sulphur dioxide unit, record the vacuum procurable.
   2. If it is a Freon or methyl chloride unit, record the head pressure obtainable.
      NOTE.—Be very careful of the high pressure gauge when doing this or it will be ruined.

H. Record any trouble apparent in the system.

I. Report to the instructor to learn whether the unit should be dismantled or not.

J. Have the job checked and marked by the instructor.

K. Answer the following questions:
   1. Describe the location of the refrigerant screens in the system.
   2. What would happen if the screen located in the liquid line of one of the coils were to become clogged?
   3. How may one determine whether a screen is clogged, whether the needle is stuck shut, or whether the low side float is oil bound?
   4. What trouble is indicated if a low side float coil frosts unevenly?
   5. Explain how oil is returned to the compressor from a low side float coil.
   6. What is meant by the congealing temperature of an oil?
   7. With what kind of refrigerant is the pan or bucket type float popular?
   8. What is meant by oil slugging in a suction line and what causes it?
   9. How tight should the V-belt be to drive most efficiently?
   10. Why is a partially restricted suction line more detrimental to a refrigerating machine than a partly pinched liquid line?

JOB NO. 27

TROUBLE SHOOTING ON A MULTIPLE DRY SYSTEM

1. *Purpose:* To become proficient in tracing trouble in a thermostatic expansion valve installation.

2. *Material:* 1 6 inch square of fine sandpaper
   1 wiping cloth

3. *Tools:* 1 complete service kit

4. *Reference:* Read Paragraphs 393–410, 413, and 414.

5. *Equipment:* One condensing unit connected to two or more thermostatic expansion valve coils.

6. *Procedure:*

   A. Follow the same procedure and record the same data in regard to the condensing unit as set forth in Job No. 24.

   B. Record the coil temperatures.

   C. Record the relative suction and liquid line temperatures.

   D. Check the location of the thermostatic power bulk and record.

   E. Record the sound of the expansion valve.

   F. Test for leaks.

   G. Determine and record the troubles, if any, in the system and report to the instructor.

   H. Have the job checked and marked by the instructor.

   I. Answer the following questions:

      1. Does a thermostatic expansion valve control the low side pressure?
      2. Does a thermostatic expansion valve control the amount of refrigerant in the coil?
      3. What refrigerant must the thermostatic element be charged with?
      4. A frosted suction line may indicate what refrigerant control troubles?
      5. What is the temperature difference between the cooling coil and the refrigerant when the compressor is running?

      6. Compile a detailed list of a typical service kit for refrigeration purposes.
      7. What is a gas charged (not refrigerant charged) thermostatic expansion valve?
      8. Why is the thermostatic bellows insulated from the expansion valve body proper?
      9. Sketch *three* methods of fastening the thermostatic power bulb to the suction line.
      10. How does one determine with what the thermostatic element of a thermostatic expansion valve is charged with?

CHAPTER XXI

ANSWERS TO REVIEW QUESTIONS

ANSWERS TO THE REVIEW QUESTIONS OF CHAPTER I

1. 25.6°C.
2. 68°F.
3. —15°C.
4. —28°F.
5. 263°C.
6. (*a*) 68, 247.54 B.T.U. per hour.
   (*b*) 884,730 foot pounds per minute.
7. 25 cubic feet.
8. 77.4 B.T.U.
9. 872.9 B.T.U.
10. 1310.52 B.T.U.

ANSWERS TO REVIEW PROBLEMS AND QUESTIONS

CHAPTER I

1. 10.7 pounds per square inch Absolute.
2. 9.43 cubic inches.
3. 135 pounds per square inch gauge.
4. 150 cubic inches.
5. 970 B.T.U.
6. 58.46 pounds of sulphur dioxide.
7. 2.7 inches of vacuum.
8. 11 pounds per square inch or 22 inches of mercury.
9. 17.5 pounds per square inch Absolute.
10. 1668 pound gauge.
11. 42°F. to 45°F.

12. The pressure exerted upon it.
13. 0 pounds per square foot gauge or 2116.8 pounds per square foot Absolute.
14. Below.
15. It is solidified carbon dioxide.
16. No, because it will create a pressure up to 1000 pounds per square inch gauge if sealed in and would burst any ordinary container.
17. Dry ice will absorb a little more than twice the heat water ice will.
18. Yes, dark colors absorb more and radiate more than bright colors.
19. A house being heated by a hot air furnace.
20. Copper is a much faster conductor of heat.

CHAPTER II

1. Four.
2. (1) Compressor, (2) condenser, (3) liquid receiver, (4) liquid line, (5) refrigerant control, (6) cooling unit, (7) motor control, (8) suction line.
3. (1) Cooling unit, (2) motor control, and (3) suction line.
4. (1) Compressor, (2) condenser, (3) liquid receiver, (4) liquid line.
5. (1) Reciprocating, (2) rotary, (3) gear, (4) centrifugal.
6. Hermetic or semi-hermetic.
7. (1) Cooling unit, (2) suction line, (3) compressor, (4) condenser, (5) liquid line.
8. To keep the high pressure from backing up into the cooling coil.
9. To enable the heat to be removed from the condenser efficiently.
10. A dry cooling coil.

11. The motor control.
12. (1) Low pressure side float, (2) high pressure side float, (3) expansion valve.
13. The eccentric crankshaft has a larger bearing area.
14. .0001 inch to .0005 inch.
15. Very small, .010 inch to .020 inch clearance is allowed.
16. Approximately .010 inch to .015 inch.
17. A low side float maintains a constant level of liquid refrigerant on the low pressure side or one may say it maintains a constant quantity of liquid refrigerant on the low pressure side.
18. The expansion valve maintains a constant pressure on the low pressure side while the compressor is running.
19. The high side float maintains a constant quantity of liquid refrigerant on the high pressure side.
20. The purpose of the crankshaft seal is to make the joint, where a crankshaft enters the compressor, leak proof.
21. Another word for evaporation of a liquid is boiling or vaporizing.
22. In Figure 24, the cooling unit tubing is enclosed or submerged in a brine tank.

ANSWERS TO THE REVIEW QUESTIONS OF CHAPTER III

1. (A) is the generator during the firing periods and is the absorber during the cooling periods.
   (B) is the water-cooled condenser.
   (C) is the liquid receiver.
   (D) is the cooling coil.
   (E) is the burner.
   (F) is the cooling water inlet to the condenser.
   (G) is the cooling water outlet of the condenser.

2. The ammonia and water combination in absorption refrigeration is popular because of the availability of the two, because of the powerful attraction the one has for the other, because of the decided temperature difference in their boiling-points, and because of the high latent heat of the ammonia.
3. The purpose of the hydrogen in the Electrolux is to provide about nine-tenths of the pressure in the cooling coil, permitting the ammonia to vaporize at a low vapor pressure. The total of the two pressures equals the pressure throughout the system.
4. Those localities in which electricity is not available as yet are ideal for the use of the kerosene-fired absorption refrigerator. Summer cottages also make a very good sales outlet.
5. Michael Faraday discovered the absorption principle in 1824.
6. The absorber in the Electrolux cycle must be cooled because when the weak water solution absorbs the ammonia gas out of the hydrogen, heat is generated and it must be removed.
7. The purpose of a heat exchanger is to exchange heat between liquids or gases at two different temperatures. For example, the liquid line of the Electrolux is surrounded by the cool mixture of ammonia and hydrogen coming from the cooling coil so that the liquid ammonia will be cooled before it reaches the cooling unit.
8. When the gas flame becomes larger the percolation action increases, forcing more ammonia gas up to the condenser, more ammonia condenses, and therefore a greater quantity of liquid ammonia will be fed to the cooling coil, producing more refrigeration.
9. The storage chamber on the receiver is insulated because otherwise it would act as a cooling coil during the freezing part of the cycle and would produce too much refrigeration.
10. These mechanisms are provided with a fuse plug because

ammonia is a high pressure refrigerant and during extreme cases such as a fire in the building the unit might blow up or explode if it were not provided with this fuse plug.

11. (1) Water, (2) silica-gel, (3) silver chloride.
12. It depends upon the compression due to the heat in the generator and upon the heat removing ability of the condenser.
13. The yellow is hydrogen, the green is cooling water, the blue is weak liquor, the purple is strong liquor, the red is ammonia, and the orange is ammonia and hydrogen.
14. It acts as the absorber during the freezing part of the cycle.
15. Yes, and they are still being used on freight cars.

ANSWERS TO THE REVIEW QUESTIONS OF CHAPTER IV

1. A conventional refrigerating mechanism is one using mechanical joints and it has enough servicing valves mounted in it to make it serviceable.
2. V-belts are the most popular type of drive.
3. Cooling coils have been made of copper and many of the companies still follow this practice. The copper is tin-plated or chromium-plated for sanitation and appearance. Lately some of the companies are producing cooling coils made of steel, having a porcelain exterior, or they are using stainless steel coils.
4. The expansion valve, the low side float, the high side float, and capillary tube are popular refrigerant controls at the present time.
5. The condenser fan is usually mounted on the electric motor shaft and is a part of the pulley.
6. The liquid receiver service valve is mounted on the base.
7. The Crosley does not use a liquid receiver because it has a capillary tube refrigerant control.

8. Flywheels are most commonly fastened to the crankshaft by means of tapered shafts and Woodruff keys.
9. Suction lines are run to the crankcase in order to permit a return of the refrigerant oil to the crankcase.
10. The condenser is cooled by a fan built into the compressor flywheel.
11. To accommodate slight changes in the amount of refrigerant in the cooling coil.
12. They are (2), (3), (6), (22), (23), (27), (30).
13. To enable placing the float control with the condensing unit and still not have a frosted liquid line.
14. In the piston.
15. Yes, it has two.

ANSWERS TO THE REVIEW QUESTIONS OF CHAPTER V

1. The hermetic refrigerating system is one with all sealed joints either soldered, brazed, or welded. It is not equipped with servicing valves.
2. The rotary compressor is an inherently smoother one than the reciprocating type.
3. The rotating blade type and the stationary blade type.
4. Rotary compressors must be equipped with check valves because the high pressure leaks back through the compressor through the bearings, etc., when the compressor stops.
5. A semi-hermetic machine is one having sealed joints, but the unit is equipped with means whereby the system may be serviced.
6. The General Electric Company.
7. The high pressure side float and the capillary tube.
8. Compressor unloading devices are usually incorporated in hermetic machines to enable the use of induction motors.

9. The extra motor is used to drive the fan for cooling the condenser.
10. The system is completely equipped with service valves and therefore gauges may be easily installed.
11. It is being subjected to the high side pressure of the system.
12. To facilitate the return of the oil to the compressor.
13. Blue and purple.
14. A horizontal, two-cylinder opposed reciprocating semi-hermetic compressor.
15. Directly driven.
16. The low side pressure of the system.
17. Thermon, sometimes known as F-21.
18. A capillary tube (restrictor).
19. 28 inches of vacuum on the low pressure side and 8 inch vacuum on the high pressure side.
20. It is a shelf across the top of the cabinet.

ANSWERS TO THE REVIEW QUESTIONS OF CHAPTER VI

1. Ammonia, hydrogen, and water are the three substances used in the Electrolux mechanism.
2. The F-11 is used to form a hot vapor bath around the generator during the heating period and to cool the generator during the absorption period.
3. The Faraday is equipped with a pilot light because the gas burns intermittently.
4. Copper tubing is used in the Faraday because dry or anhydrous ammonia is used as the refrigerant.
5. The Faraday water valve is operated by the temperature of the exhaust water. If the water leaving the unit becomes warmer, the valve opens farther and conversely.
6. The water cools the F-11 refrigerant, which in turn cools the absorber.

7. The temperature control valve permits only liquid ammonia to go into the cooling coil during the generating period and maintains any desired pressure in the cooling coil during the absorption period.
8. The purpose of (11) in Figure 82 is to store the extra hydrogen which is used only when the unit is working in extremely warm weather.
9. The purpose of the methyl chloride in the air-cooled Electrolux is to cool the absorber, the methyl chloride in turn being cooled by the air in the room.
10. The kerosene used for the intermittent absorption machines must be very clean and dry otherwise it will emit a smudge and odor.
11. By controlling the size of the gas flame.
12. The upper coil is the cabinet cooling coil while the lower coil is used to produce ice cubes.
13. To permit feeding the cooling coil with liquid refrigerant.
14. Ammonia.
15. It is used to hold the condensing water, which in turn surrounds the condenser coils.

ANSWERS TO THE REVIEW QUESTIONS OF CHAPTER VII

1. (A) is the connection to the gas supply.
   (D) is the bi-metal disk which snaps the knob open or closed as its temperature changes.
   (H) is the manually adjusted needle valve for controlling the maximum amount of gas to be burned.
   (L) is the fine mesh screen which keeps the dirt in the air out of the burner.
   (O) is the burner proper.
2. A thermostatic motor control must be used with an automatic expansion valve because the pressure type cannot be

used, due to the expansion valve maintaining a constant pressure on the low side while the compressor runs.

3. A screen is always so located that the refrigerant must go through it before it comes to the control needle to eliminate as much as possible any dirt from lodging between the needle and seat.
4. The pressure and thermostatic types of motor controls are very similar, inasmuch as refrigerant temperatures and pressures are very closely correlated. When the pressure increases the temperature rises and conversely.
5. (1) It maintains certain temperatures in the cabinet and (2) it controls the cycling time of the refrigerating unit.
6. In an Electrolux water-cooled unit the thermostatic gas control has an extra device consisting of another power element located at the water coils. If the water were to shut off, this thermostatic power element upon warming up would shut off the gas supply.
7. There are three types of differential adjustments: (1) it adjusts the cutting-in point only, (2) it adjusts the cutting-out point only, and (3) it either spreads the two farther apart or brings them closer together.
8. Calibrating a float is to fix the float so that the liquid refrigerant will be at a certain level when the needle closes.
9. The gas pressure in a gas burning refrigerator must be carefully maintained at a constant pressure to insure against rapid fluctuations of the flame.
10. The suction line extends to the bottom of the pan type float to remove any collection of oil or liquid refrigerant from it.
11. Thermostatic motor controls are usually charged with a refrigerant.
12. Hermetic motor controls must have an external mechanism to connect and disconnect the starting winding. A starting relay is used to do this task.

13. To permit the use of different refrigerants and to compensate for altitude.
14. The needle metal is usually harder than the seat metal, i.e., stainless steel, Stellite, etc.
15. The ball type and the open pan type.
16. The high side float and the capillary tube.
17. The range adjustment controls the cabinet temperature.
18. The differential adjustment controls the cycling interval time of the refrigerator unit.
19. A hand switch, a manual shut-off and automatic turn-on, and a clock.
20. A heating coil which melts a soldered connection when too much current is drawn. The solder in turn releases a spring which pulls the points open.

ANSWERS TO THE REVIEW QUESTIONS OF CHAPTER VIII

1. Simple induction motors, repulsion induction motors, and capacitator motors are the three used in domestic refrigeration.
2. Two separate field windings are used in 100 and 220 volt motors. These windings are connected in parallel when used with 110 volts and in series when connected with 220 volts.
3. The motor must be cleaned regularly because like any other mechanical apparatus, dirt soon causes excessive wear of the bearings and deteriorates the parts.
4. All repulsion induction motors do not have the brush lift mechanism because this is only a device to enable the brushes to last longer.
5. The commutator short circuiting device is the mechanism which converts the motor from a repulsion-start motor into an induction motor by preventing the building up of any

electrical currents in the armature. The short circuiting takes place when the motor has reached approximately 75 per cent of its maximum R.P.M.

6. The two types of commutators used in the repulsion induction motors are: (1) The cylindrical type in which the commutator bars form a cylinder and the bars are built parallel to the armature shaft. This type usually has brushes that are not lifted.
(2) The radial type of commutator has the bars constructed perpendicular to the armature shaft similar to the spokes of a wheel.
7. Emery cloth is not recommended for commutator cleaning because the emery tends to short-circuit the bars and also it causes considerable arcing to take place, which naturally deteriorates the commutator and brushes very rapidly.
8. A plug fuse is inadequate motor protection because it must have an amperage capacity great enough to stand the starting load of the motor, and the same capacity if drawn continuously by the motor will burn the motor windings.
9. A capacitator motor has an advantage over the repulsion-start induction motor in that it has no commutator or brushes. It does, however, use a centrifugal switch.
10. The burners in the kerosene and gas fired refrigerators must be kept clean and dry because they will otherwise emit an unpleasant odor.
11. It depends on the design; if the time intervals are not placed on the motor name plate, one to two drops each month will answer most of the motor requirements.
12. To reduce the vibration transmitted to the cabinet.
13. Induction motors.
14. 32, 115, 230 volts.
15. By grounding the motor to a water pipe or by connecting a condenser from the motor to the ground.

ANSWERS TO THE REVIEW QUESTIONS OF CHAPTER IX

1. To keep the heat leakage into the cabinet to a minimum and therefore to reduce the cost of operation.
2. Approximately 3 inches.
3. Because the inside temperature of the cabinet is cold enough to make moisture precipitate out of the air. If the insulation is not water proof, the moisture will collect in it and ruin its insulating ability.
4. This is the cubic feet of space in which food may be stored.
5. (1) In the top of the cabinet, (2) in the base of the cabinet, and (3) remote.
6. To enable an easy means of breaking the frozen contact between the tray and the shelf.
7. The frost acts as an insulation and also stores food odors.
8. Approximately ¼ inch.
9. A luke warm baking soda and water solution.
10. By washing them with vinegar.
11. (1) Corkboard, (2) dry-zero, and (3) metal foil.
12. By means of a rubber gasket which is slightly compressed when the cabinet door is closed, sealing it.
13. (1) Upper right hand corner, (2) upper left hand corner, (3) upper middle, and (4) across the top of the cabinet.
14. Because warm air rises and cold air falls, the location of cooling coil at the top of the cabinet promotes air circulation and uniform temperature.
15. The very cold cooling coil will draw the moisture out of foods (dehydrate) unless they are protected.

ANSWERS TO THE REVIEW QUESTIONS OF CHAPTER X

1. A self-contained installation is one having the complete refrigerating machine mounted in the cabinet.

2. A remote installation is one having the condensing unit located outside the cabinet.
3. Because a blast of air is continually forced over the air-cooled condensers in most machines, this air circulation deposits dust and lint between the fins of the condensers. This dirt accumulates and eventually restricts the air flow over the condenser to such an extent that very inefficient cooling results.
4. A distributor of electrical refrigerators should operate each and every refrigerator for 24 hours, checking it thoroughly for correct functioning, before delivering it to the purchaser.
5. A good method for providing positive rear ventilation of a base located condensing unit is to attach strips of wood or metal to the rear of the cabinet in such a manner that the cabinet cannot be pushed tight against the wall.
6. If a refrigerating mechanism is shut down for 48 hours or more the pressures in the system equalize and become the pressure corresponding to the room temperature. The result of this is that condensation of refrigerant will take place in the crankcase of the compressor, and when the unit is started again in addition to having an over-loaded compressor because of the excessive low side pressures the liquid refrigerant vaporizing in the crankcase emulsifies the oil. These two conditions occasionally break down the machine, and the reason for this is the stirring up of the complete system to the extent that any dirt particles which may have settled in the screen and odd crevices will again be in circulation.
7. Thorough dehydration of any refrigerating machine is absolutely necessary if long continuous efficient operation is desired. For some refrigerants the trouble is apparent sooner than in others, but moisture will eventually ruin any system regardless of the refrigerant.
8. The refrigerant must be removed from the low side of the system and stored in the condenser and liquid receiver if the unit is to be shut off for any length of time. This prevents the building up of high pressures in the low side and also eliminates the condensation of liquid refrigerant in the crankcase.
9. The opening through which the tubing enters the cabinet is always sealed because the temperature differences between the air in the cabinet and the air outside would result in a continuous rapid exchange of heat at this point.
10. It is best to allow a refrigerating machine to refrigerate continuously for its full life and never allow it to be turned off for more than 6 hour periods. This enables the machine to settle down to one continuous routine and permits a harmonic operation of all of the various parts of the system. It is the best insurance for a long continuous and efficient life of the mechanism.
11. To allow correct oil levels, and to permit correct operation of the float mechanisms.

ANSWERS TO THE REVIEW QUESTIONS OF CHAPTER XI

1. In air-cooled units a hot liquid line indicates a lack of refrigerant in the system.
2. Most of the units have service valve stems which use ■ ¼ inch square opening wrench. Some of the companies, however, use a 3/16 inch square opening wrench.
3. Controls are tested with dry air to eliminate the condensation of moisture on the internal parts of the mechanism.
4. A pounding noise in the compressor when the compressor starts to pump a vacuum is indicative of oil pumping. (This is hard on the compressor and the compressor should be stopped.)

5. After gauges have been installed in the system, they should be carefully tested for leaks because (1) in case the low side is under a vacuum, a leak will permit the air to go into the system; (2) if the pressure in the system is higher than atmospheric pressure the refrigerant will leak out and be irritating to the service man if it is an irritant refrigerant, while in all cases it will make it difficult for the service man to detect the exact source of permanent leaks in the system; (3) the leakage of refrigerant at the gauge joints occasionally spoils the accuracy of the gauge reading.

6. A halide torch must be charged and pumped up to its pressure outside the rooms where the refrigerating mechanism is located because if any refrigerant is put into the torch either through the medium of air or by means of the fluid itself, the torch will burn continuously with the leak detecting color destroying its usefulness. If this has been done the torch must be thoroughly cleaned with carbon tetrachloride to make it usable again.

7. Service valve packings are made of asbestos covered with lead sheet and graphite.

8. An exhaust valve seat is best lapped on a lapping block, first using a fine alundum lapping powder and refrigerant oil. A figure eight motion should be used and the valve plate should be continuously turned under one's hand. Remove all the lapping powder and clean both the block and the valve plate with oil after all the crevices have been removed from the valve seat and then polish the same by lapping it on the same block but using refrigerant oil only.

9. An air-cooled sulphur dioxide system having a 110 pounds per square inch head pressure indicates the following troubles in the order of their possibility:
   (1) Air in the system.
   (2) Externally restricted condenser.

   (3) Poor circulation of air in or out of the condensing unit.
   (4) Too much refrigerant in the system.
   (5) Too much oil in the system.
   (6) An extremely warm room.

10. A frosted suction line with an above normal low side pressure indicates:
   (1) With an expansion valve refrigerant control this means that the expansion valve adjustment is turned in too far or that the needle and seat are leaking.
   (2) With low side float system this means that the needle and seat are leaking or that the float is calibrated too high, or that the float ball itself has sprung a leak.
   (3) With a high side float system this means that the system is charged with too much refrigerant or that the needle and seat are leaking.
   (4) Capillary tube systems have this trouble if they are charged with too much refrigerant.

11. In the low pressure side on the S.S.V.

12. In the high pressure side on the D.S.V.

13. To prevent a flow of air into the system or of gas out of the system.

14. Approximately 6 inches of vacuum.

15. Approximately 85 pounds per square inch.

16. The preeautions are:
   (1) The charging line must be in excellent condition.
   (2) One should wear goggles.
   (3) The charging line should be purged.
   (4) Only the specified amount should be added to the cylinder (85 per cent full).

17. Because the valve stem controls two different openings.

18. The four common expansion valve troubles are:
   (1) Leaking needle.

(2) Out of adjustment.
(3) Moisture on the bellows.
(4) Moisture at the needle.

19. This moisture will freeze and prevent any movement of the bellows keeping it open continuously or closed almost continuously.
20. Immerse the float ball in very hot water and watch for bubbles.
21. Pass a swab saturated with 28 per cent aqua ammonia around the joints (do not touch any parts) and watch for white fumes which indicate the presence of sulphur dioxide fumes.
22. Pass the suction tube of the lighted halide torch close to the connections suspected of leaking and if the flame becomes a brilliant green a leak is present.
23. A higher-than-normal head pressure.
24. The two methods are:
    (1) Balancing the pressure in the crankcase and adding the oil through the oil plug opening.
    (2) By sucking the oil in through the S.S.V. gauge opening.
25. To remove all the refrigerant from the oil by purging this gas out the D.S.V. gauge opening.

ANSWERS TO THE REVIEW QUESTIONS OF CHAPTER XII

1. Several combinations of fittings may be used to do this connecting:
    (*a*) The reducing fitting (half union) may be used having a 1/8 inch pipe, female thread, and 1/4 inch pipe male thread.
    (*b*) A length of tubing may be used to convert as follows: Put a 1/8 inch pipe female to ■ 1/4 inch S.A.E. flared fitting (half union) on the gauge. Connect the tubing to this fitting by means of a 1/4 inch S.A.E. flare nut and connect the other end of the tubing by means of a 1/4 inch S.A.E. flare nut to a 1/4 inch S.A.E. flare by 1/8 inch pipe male half union.

2. The two precautions to be observed when cutting tubing with a hack saw are that the tubing must be cut square and the saw chips must not be permitted to fall into the tubing which is to be used.
3. The thread size of a 1/4 inch S.A.E. flare nut is 7/16 inch—20 S.A.E. For a 3/8 inch S.A.E. flare nut 5/8 inch—18 S.A.E. For a 1/2 inch flare nut, 3/4 inch—16 S.A.E.
4. The thickness of refrigeration tubing is .035 inch. The inside diameter of ■ 1/4 inch tubing is therefore, .180 inch or approximately 3/16 inch.
5. The refrigerants to be used in the refrigerator systems should be thoroughly analyzed for impurities, because small amounts of certain impurities will tend to deteriorate the system excessively.
6. One must be careful when handling most of the refrigerants because they are under pressure high enough to be injurious when subjected to room temperatures. One must be especially careful of joints when transferring refrigerants because the breaking of a joint might permit some of the refrigerant to strike one on the face or eyes and the extremely low vaporizing temperatures of the refrigerants may permanently injure the sight.
7. The refrigerant cylinder to be used should have an I.C.C. and a date stamp on it. An old drum is liable to burst with serious or fatal results.
8. Domestic brine solutions should be made strong enough to freeze at temperatures of 0°F. This enables the brine to

still have good convecting qualities when subjected to 10°F. and 15°F. temperatures.

9. Glycerine is considered the ideal brine because it is non-corrosive, non-odorous, and non-evaporating.

10. A reversible ratchet wrench has an inherent safety device in that in case a bad leak should occur when using it the valve stem can be quickly turned off again by simply reversing the ratchet.

11. The two kinds of service repair shops are: (*a*) the type which caters to independent service men, (*b*) the type maintained by a large service company for their own use.

12. A lathe may be used for the following work:
    (1) To true up shafts including crankshafts and armatures.
    (2) To reface armatures commutators.
    (3) To reface valve seats.
    (4) To reface crankcase seal disks and sylphon bellows rings.
    (5) To open liquid receivers.
    (6) To wind tubing into cylindrical forms.
    (7) To grind crankshaft seal shoulders.

13. Two types of charging stands being used at the present time are:
    (1) Dispensing the refrigerant directly from the stored cylinder into the service cylinders and determining the amount transferred by weighing the cylinder into which the refrigerant is transferred.
    (2) The other stand uses an intermediate cylinder equipped with a glass sight level gauge. The refrigerant is removed from this intermediate cylinder into the drum to be charged and the change in the liquid level in the sight level gauge indicates the amount transferred.

14. An air dryer is necessary in the inlet of the air compressor

to enable the obtaining of dry high pressure air. If this dryer is not used, moisture condensation gradually accumulates in the air storage tank and eventually the compressed air is made unsuitable for blowing out parts of the refrigerating system.

15. Three kinds of lapping blocks or surfaces are:
    a) A flat plate surfaced with fine sandpaper or polishing paper.
    b) Plate glass.
    c) Seasoned cast iron blocks with a very accurately ground and lapped flat surface.

16. A compressor should be run at its rate of speed when testing it for efficiency to obtain a true picture of how much it can pump. The volumetric efficiency of a compressor decreases as the speed increases and conversely. For this reason the only accurate test is to run the compressor at its rated speed.

17. "Baking" a compressor is to keep it at 200°F. to 250°F. for a period of 8 to 24 hours with the 24-hour period recommended. This will drive any moisture out of the compressor, leaving it thoroughly dehydrated.

18. The exhaust fan of a refrigerating repair shop is usually located near the floor because most of the refrigerants in a gaseous form are heavier than air.

19. Goggles, rubber aprons, and rubber gloves should be used when working with the acid dip bath to minimize chances of being blinded or of getting severely burned by the acid. This is a safety precaution that should always be followed.

20. The fire hazard in a paint spray booth comes from the use of thinners and nitrate paints which are explosive when very finely atomized. The paint spray booth should, therefore, be shielded from any open flames in the room and it should have a separate adequate exhaust fan to remove the paint

fumes as rapidly as they are formed. The best solution to the problem is to have the paint spray booth located in a separate room.

ANSWERS TO THE REVIEW QUESTIONS OF CHAPTER XIII

1. The temperatures desired in commercial refrigeration are as follows: (1) Water-cooling installations have a water temperature 40°F. to 55°F. (2) Walk-in coolers 36°F. to 40°F. (3) Florist cabinets 50°F. to 60°F. (4) Ice cream cabinets 0°F. to 12°F. The minimum temperature encountered in commercial refrigeration is for the maintenance of brick ice cream which needs a temperature of 0°F. The manufacture of ice cream in small quantities is becoming popular and in commercial installations of this type temperatures of —10°F. are desired for hardening.
2. The joints between the doors and their frames and between windows and their frames must be air-tight in refrigerator cabinets or a continuous air circulation will occur due to the temperature differences. This will increase the cost of operation.
3. The windows of the refrigerator cabinet are usually of the two or three pane construction having one and two dead air spaces respectively. The glass itself is a very poor insulator so the dead air spaces are used to provide the insulation. Theoretically, dead air is one of the best insulations, but in the case of this kind, the radiation load into the cabinet is high and the dead air spaces are so large that internal convection takes place permitting heat to pass into the cabinet relatively easy.
4. The dead air space formed by these window panes must be kept free from moisture to stop fogging or moisture precipitation on the inner pane. This is done by using a moisture absorbing chemical such as calcium chloride.

5. The lights of display counters are usually mounted outside of the cabinet because they produce considerable heat and it is therefore more economical to have them mounted outside.
6. The average temperature of a walk-in cooler may be found half way between the cold and warm air flues of a cabinet, 2 inches away from the wall that is farthest from the door, and about 4 feet from the floor.
7. Most commercial installations are of the multiple type because this permits the use of a smaller condensing unit inasmuch as the peak loads of the various cabinets do not occur at the same time. With one cabinet or in a single installation the unit must be large enough to take care of the peak load.
8. (1) Water in a heat treating room of a tool and die factory should not be cooled lower than 50°F., while 55°F. is recommended.
   (2) A water temperature of 40°F. to 45°F. will be found satisfactory for an office building.
9. The length of the counter determines the number of coils because of the air circulation. The circulation must be greater in the horizontal direction than it is in the vertical direction which tends to slow it up considerably. To minimize this horizontal air circulating distance, coils are placed at both ends of the counter.
10. The moisture content in the air is very important in produce storage cabinets because most of the material stored has a very high moisture content. If the air in the cabinet is dry this dry air as it circulates over the material will remove some of the moisture from them, spoiling the appearance and decreasing the weight of the material.
11. A thermostatic expansion valve is a refrigerant control

operating on the basis of the coil temperature pressure. A thermostatic element is connected to the needle of the valve with the thermostatic bulb of the thermostatic element clamped to the outlet of the coil. This bulb when warm produces a pressure in the bellows, making it expand, which opens the needle and allows the refrigerant to enter the coil. This refrigerant, as it passes along the coil tube, boils and produces cooling. When enough of it enters the coil so that boiling of the refrigerant starts to take place at the point where the power bulb is located, the power bulb is cooled, decreasing the pressure in the bellows which closes the valve. Under correct operating conditions the thermostatic expansion valve will keep the coil filled with a semi-liquid and gaseous refrigerant independent of the operation of any other coil in the system as long as the compressor is running.

12. The low side float refrigerant control uses considerably more refrigerant than a thermostatic expansion valve for the same cooling capacity. This is due to the need of a float chamber in the coil to operate the low side float.

13. The advantage of a non-frosting cooling coil is that it maintains a constant heat removing efficiency without needing any attention; and its operation is such that it does not remove the moisture from the air very rapidly, permitting a higher relative humidity to be maintained in the cabinet.

14. All the tubing connections and the coil connections inside a cabinet should be soldered principally because of the destructiveness of moisture freezing between the nut and the tube. This will sometimes cause either the nut to crack or the tube to be pinched together.

15. A high pressure motor cut-out switch should be installed on all water-cooled condensing units because of the danger of an inadequate water supply. If the water were to be restricted

in its flow, the resulting excessive head pressure would soon burn out the motor unless the safety cut-out functions.

16. Intake valves of a compressor are frequently located in the head of the piston, although some companies locate them in a valve plate, while others use valve ports cut into the cylinder walls.

17. It is advisable to connect the high pressure motor cut-out bellows to the cylinder head of the compressor because this facilitates the removal of the valve for servicing.

18. The three types of water valves are: (1) the electrically operated type, (2) the pressure operated type, (3) the thermostatic type.

19. (1) The metering, two-temperature valve; (2) the snap-action, two-temperature valve; (3) the thermostatic, two-temperature valve.

20. The advantage of a water-cooled condenser over an air-cooled condenser is that it enables lower head pressures thus permitting greater capacity and reducing the wear on the moving parts of the system. Another advantage is that the condensing unit may be installed in small, out-of-the-way corners without decreasing its efficiency. However, the use of water means an additional expense of operation and occasionally localities are found wherein the water is corrosive to the water-carrying tubes. The advantage of the air-cooled condenser is that it is a simpler mechanism, has a cheaper first cost, allows for an easy installation, and may be used anywhere that sufficient air is available. The disadvantages are that the room in which the condensing unit is installed must be of sufficient size to provide enough air for cooling, the fan produces some noise, and because of the higher temperature of the cooling medium, the head pressure in the system is greater which reduces its capacity.

21. The forced circulation cooling coil takes up little space, needs no baffles, and cools the produce very rapidly.
22. (1) 0°F. for the brick ice cream; (2) 10°F. for the vanilla ice cream; (3) 5°F. for the other bulk ice cream; (4) 40°F. for the beverages; (5) 45°F. to 50°F. for the syrups.
23. To enable one motor control to control the cooling of all the coils connected in that system.
24. The check valves are located in the suction lines of the coldest coils.
25. The coils controlled by the two-temperature valve should not exceed 40 per cent of the total refrigeration load.

ANSWERS TO THE QUESTIONS OF CHAPTER XIV

1. A B.T.U. is the amount of heat required to change the temperature of 1 pound of water 1°F.
2. 2545.6 B.T.U. per hour equals 1 H.P.
3. Sensible heat is heat which causes a change of temperature.
4. Latent heat causes a change of state.
5. Specific heat of a substance is the heat required to change the temperature of 1 pound of that substance 1°F.
6. The use to which the cabinet is put determines to a considerable extent the usage heat load.
7. This is a common calculating basis, easy to measure, and experiments point to it as the most accurate surface to use.
8. To promote air circulation in a cabinet.
9. To prevent a heat transfer from the cold air coming from the coils to the warm air going to the coils.
10. Spruce or fir wood.
11. To give adequate refrigeration during rush periods.
12. The ice pressure would burst the container.
13. .45 B.T.U. per pound.
14. At 0°F.
15. 6 pounds per gallon.

16. The temperature of the gas becomes 10°F. to 12°F. warmer than the refrigerant temperature in the coil.
17. The effective latent heat is the actual amount of heat removed from the cabinet for each pound of refrigerant evaporated, while latent heat is the total amount of heat absorbed by the refrigerant but part of which is used to cool its own liquid down to the evaporating temperature.
18. The addition of heat due to compression.
19. Because all energy units are mutually convertible. The mechanical energy of the motor produces heat energy.
20. Volumetric efficiency is the amount of gas actually pumped per revolution of the compressor divided by the piston displacement of the compressor. It is effected by the speed, the valve design, the piston clearance, the head clearance, the compression ratio, etc.
21. The size of unit, the compactness desired, the kind of unit, the locality, etc.
22. Motor efficiency is the ratio of the mechanical power output to the electrical power input and it varies between 50 per cent and 90 per cent depending on the size of the motor.
23. (1) Heat travels from the food to the air with difficulty.
    (2) Heat travels from the air to the coil with difficulty.
    (3) Heat travels through the coil metal very efficiently.
    (4) Heat travels through the oil film with some difficulty.
    (5) Heat travels into the refrigerant with ease.
24. The greater the speed the more the capacity because the more air is passing by the surface to remove heat.
25. The oil film acts as a retarder to the heat travel.
26. The gas flows only because of a difference in pressure; therefore the farther the suction line runs from the condensing unit the greater difference in pressure there will be between the ends, the higher pressure being at the cooling coil.
27. Yes.

ANSWERS TO THE QUESTIONS OF CHAPTER XV

1. Code installations require that the refrigerant tubing be installed in conduit because it is believed that this construction will prevent accidents and gives the tubing additional support.
2. Hand valves are provided in the refrigerant lines leading to each individual coil to facilitate servicing and to permit disconnecting that coil in case of an accident.
3. It is recommended that tubing be run parallel with beams rather than across them to give additional protection.
4. It is absolutely necessary to mount a float valve level in order to permit the float to operate correctly. If not in a level position, the float will be out of calibration and cannot function properly.
5. Two-temperature valves are usually located on the manifold wall boards.
6. "Greenfield" tubing is flexible metal conduit.
7. After assembling a dry multiple coil system, it is necessary to remove the air and other foreign substances within the coils and the lines. To do this, one should close all the hand valves except the liquid line hand valve for one coil. The suction line of this same coil should be left loose at the hand valve and the liquid receiver valve cracked. The surge of a small quantity of the gas will force the air out of this loose connection and after one detects the odor of the refrigerant, the joint is tightened and the valves closed. Repeat this for each coil until all the coils have been purged. This will remove all the air from the installation except from the main suction line. This main suction line may now be purged by leaving the connection at the compressor loose and purging the gas through one of the coils down the suction line and out of the loose connection. With all the connections tight and all the hand valves open and with the liquid receiver valve shut a vacuum should now be drawn on the installed part of the system. The gas evacuated is discharged out the compressor discharge service valve, it being turned all the way in. If the gas is irritant, a neutralizer will have to be used here to eliminate the annoying odor. The machine may now be started, opening one coil at a time and allowing 15 minutes between each coil to reduce the starting load on the condensing unit.
8. Under normal conditions it is not necessary to dehydrate the system because all the parts installed have been previously dehydrated and sealed before being connected into the system.
9. The purpose of a dehydrator in a new methyl chloride installation is to positively insure that no moisture is present within the system. The dryer the refrigerant, the longer the life of the unit.
10. Hard drawn copper tubing and streamlined fittings are becoming popular because of the rapidity with which they may be installed and because tubing of this type may be obtained in sizes much larger than is obtainable in the soft copper.
11. The indication of a lack of refrigerant in a multiple low side float system is a continuous hissing sound in the most remote coil along with a relatively warm liquid inlet connection.
12. The troubles which may result in a coil frosting excessively at the valve but being dry at the other extreme are: (1) Partially clogged screen; (2) lack of refrigerant in a thermostatic element if it is a fairly warm coil; (3) power bulb located too close to the coil; (4) moisture on the bellows.
13. (1) By using a rubber seal, (2) by using a drilled frostproof unit, (3) by shellacking the joint between the nut and the tubing.
14. A service man does not have to remove the refrigerant from a coil in case of a clogged screen because the clogging of the

screen has permitted all the refrigerant to be removed from it before the service man arrives on the premises. It is, therefore, only necessary that the service man balance the pressure, isolate the system, clean and dry the joints to be opened.

15. If a multiple system is running under a 5 inch vacuum the system must be stopped to permit the low side pressure to build up to 0 pounds per square inch, before a coil can be removed from the system. That is, (1) remove the refrigerant from that system to be opened by closing the liquid line valve; (2) permit the compressor to run until that part of the system becomes warm, indicating that all the refrigerant has been removed; (3) stop the compressor for a few minutes until the compressor pressure reaches 0 pounds per square inch; (4) shut off the suction line valve which controls that part of the system to be opened.

16. Many service men follow a practice whereby the charging cylinder is fastened to the discharge service valve in the system and then heated to drive the liquid from it into the system.

17. The four most important safety precautions to be observed when charging a system through the high side are: (1) Be very sure that the flares on the charging tubing are in excellent condition. (2) Do not heat the service drum any warmer than is comfortable to the hand. (3) Mount the refrigerant drum securely thereby eliminating any accidental twist or sudden strain on the charging tubing. (4) Wear goggles.

18. Flange fittings soldered to the tube and to the coil is the recommended method of making connections inside a cabinet. This practice permits an easily dismantled connection and it is frost-proof. Either paper or lead gaskets may be used between the two flanges while Monel or heavy cadmium plated bolts must be used to fasten the flange shoulders together.

19. The purpose of felts and fine mesh screens in a dehydrator is to insure that none of the moisture absorbing substance will circulate through the system.

20. The system should be very carefully checked for leaks if a lack of refrigerant is discovered in the system, because under normal conditions it takes 5 to 10 years before the refrigerant can leak out the small undetectable crevices. It is a waste of refrigerant and of time to simply charge the system with refrigerant, and a conscientious service man will sometimes spend considerable time checking for leaks.

21. A dehydrator removes moisture while a neutralizer reduces the acidity of the refrigerant.

22. (1) Not to buckle it. (2) To provide for adequate oil return to the compressor.

23. If left in an open container it will soon become saturated with moisture and be useless.

24. Carbon tetrachloride.

25. (1) Poor motor control. (2) Lack of water. (3) Air in the system.

ANSWERS TO THE QUESTIONS OF CHAPTER XVI

1. Ammonia is not popular in the compression type of domestic machines because it needs water-cooling to be efficient.

2. One may test for sulphur dioxide leaks with a 28 per cent aqua ammonia solution after having built up a positive pressure in the system. A leak will be detected by the appearance of white fumes when the two gases mix.

3. Ethyl chloride has been discontinued as a domestic refrigerant because of its flammability and because of lubrication troubles.

4. A common head pressure for air-cooled sulphur dioxide is

between 70 pounds per square inch and 80 pounds per square inch gauge. This pressure is registered while the compressor is running. It differs from the chart temperature slightly because the sulphur dioxide gas in the condenser is 30°F. to 35°F. warmer than the room.

5. A halide torch is the best method of testing for methyl chloride leaks.
6. With a refrigerant temperature of 5°F., that is, the coil itself will be around 15°F., the sulphur dioxide pressure should be 6 inches of vacuum and the methyl chloride pressure should be 6 pounds per square inch gauge.
7. Halide means all those refrigerants of the halide family, those that have fluorine, chlorine, bromine, and iodine in them. They have the property of breaking down into their more common substances when heated in the presence of copper, producing the characteristic color.
8. The best halide torch fuel is Formula No. 1, ethyl alcohol. One should use alcohol with very little dirt or moisture in it.
9. Carrene is used by the Household Utilities Corporation in their Grunow Refrigerator and also by the Carrier Corporation in some of their air-conditioning machines.
10. A sulphur dioxide oil must be thoroughly dehydrated and must contain no foreign elements such as free sulphur, carbon, or dirt.
11. Methyl chloride oil must also be dehydrated and cannot contain sulphur, free carbon, or dirt. In addition to this it must be a mineral oil.
12. Freon.
13. 63 pounds per square inch gauge.
14. 17°F.
15. 294 pounds per square inch gauge.
16. No, it is not.
17. By adding 30°F. to 35°F. to the room temperature and using this temperature as the refrigerant temperature obtaining the head pressure from the refrigerant chart.
18. The Crosley rotary unit.
19. Freon, Thermon, methyl chloride, F-114, ethyl chloride, and Carrene.
20. 6 pounds per square inch gauge.

ANSWERS TO THE REVIEW QUESTIONS OF CHAPTER XVIII

1. The temperature of the surroundings determine whether sensible heat will flow into the body or out of it. The humidity of the air surrounding the body determines how fast the perspiration may evaporate from the body.
2. The general humidity conditions indoors during the winter seasons are much too low.
3. Relative humidity is the ratio of how much moisture is in the air to how much would be necessary to saturate the air under the same conditions.
4. Humidity is measured by the use of a wet and dry bulb thermometer or by a direct-reading hygrometer.
5. A psychrometric chart is a graph representing the proportions of moisture and air under all combinations, assuming at standard atmospheric pressure.
6. The complete air-conditioning plant consists of: (1) heating equipment; (2) humidifying equipment; (3) filtering and cleaning equipment; (4) air circulating equipment; (5) dehumidifying equipment; (6) cooling equipment.
7. "Effective temperature" is how comfortable one feels under a combination of temperature, humidity, and air motion.
8. It is used to remove dust particles and certain bacteria which are always in suspension in the air. The dust and bacteria are detrimental to comfort and health.

9. By the use of warm water pans in the air stream or by using warm water sprays.
10. Humidity is usually decreased by cooling the air below its dew point temperature. Occasionally chemicals are used which absorb moisture from the air.
11. The central plant, the remote plant, and the unit air-conditioner.
12. Thermostatic expansion valves and solenoid refrigerant shut-off valves are commonly used.
13. The solenoid refrigerant control valves are used to control the start and stop of refrigeration or cooling.
14. The air-conditioned structure must be well insulated depending upon the locality. The roof, the windows and the doors must be specially designed if any success is to be had with the equipment at a reasonable operating cost.
15. Printing, textile, baking, furniture, and drug making plants have all used air-conditioning for some time.

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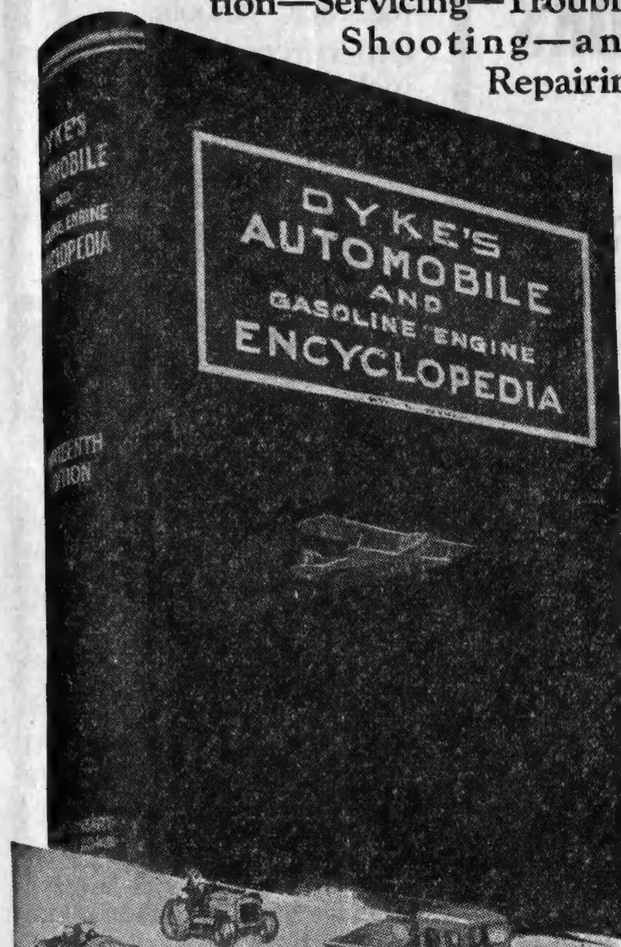

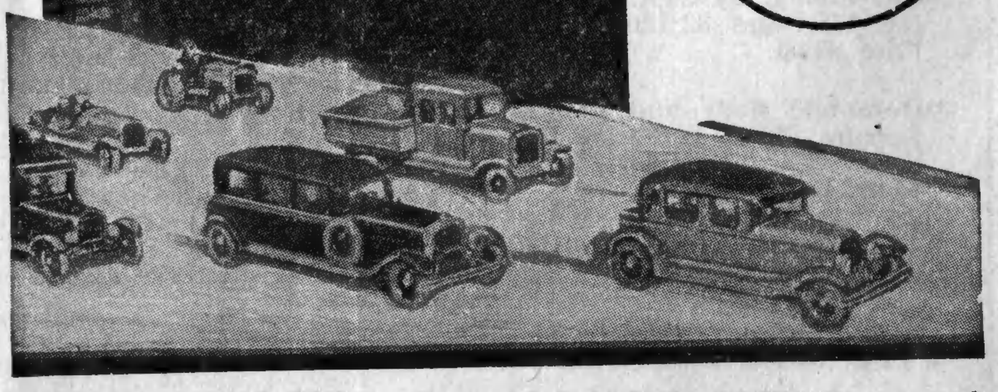

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